THE
ENGINEERING REVIEW.

Edited by
C. EDGAR ALLEN.

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WITH this number THE ENGINEERING REVIEW completes the first year of its existence as a Review, using this term in its strict sense. In this short period it has attained a distinctive and representative character by reason of the fact that it is now the only British Journal of its kind published.

For over five years previously it had enjoyed an extensive reading and advertising patronage as a Magazine, and that under a title which inadequately indicated, to those unfamiliar with it, the scope and nature of its contents.

A Magazine, however, is one thing and a Review another; and in noting that the mass of periodical technical literature was a constantly growing one, it was thought that something at once more comprehensive and technical was needed to adequately record the progress of scientific engineering than could be logically dealt with in a Magazine, by which term is understood a medium for articles of a popular descriptive type, whether as applied to technical or everyday subjects. Hence in deciding to change the scope of the Paper it became necessary to change the title also.

Naturally so radical a transition could not be made in a very brief period, and it is only within the last month or two that THE ENGINEERING REVIEW may be said to have fairly got into its stride.

The favour, however, with which the change has already been greeted, and the many encouragements received, have been a source of no little gratification to the publishers and staff, who have found in the abundant appreciative testimony conclusive evidence that the new programme is not likely to be an unsuccessful one.

Notwithstanding these facts, it is intended in the forthcoming year to make other improvements which will still further emphasise the distinctive character and value of the publication alike in its purely technical and business aspects, and it will be the constant endeavour of the publishers to cater for the needs of the general engineer arising from his professional duties, and which are not or cannot be met by the ordinary trade newspaper.

In this the Editor will be assisted by a staff, every member of which is an expert in his own department, and every confidence is felt by the publishers that THE ENGINEERING REVIEW will, in the forthcoming year, more than ever warrant the support and encouragement of those engaged or interested in the particular branch of industry which it represents.

C. EDGAR ALLEN, *Editor.*
CHAS. H. LUKE, *Managing Director.*

Some Difficulties in Getting on.

A GOOD many people have considered the problem "How to get on in the World," and some who commenced its study twenty or thirty years ago are still awaiting a complete and satisfactory solution. The fact is it would never do for everybody to get on, that desirable process being reserved by a wise dispensation of nature for a favoured few. In the present day there are too many aspirants for worldly success, as the managers of industrial works are beginning to understand. In electrical engineering works there are so many pupils, apprentices, improvers, and ex-improvers, that the manager is at times inclined to objurgate all those who consent to fill places at the machine or the bench with the hope of securing a better position, and to sigh for good workmen whose ambition is limited to the earning of his week's wages. In other spheres of electrical practice the young man who wants to get on experiences a somewhat similar form of passive resistance on the part of an indifferent world. A young electrical engineer may be as good as Sandford and Merton, and be filled with good maxims from Foster, Todd, and Smiles, but without suitable opportunities he will fail to make progress. At the present moment it is probable that more than a thousand students of the Institution of Electrical Engineers are inquiring with more or less earnestness into the problems to which we refer, an investigation which we feel sure will be assisted by the extremely practical and entertaining address recently delivered by Mr. Swinburne. This address, although intended primarily for the benefit of embryo electricians, will also be found useful to beginners in every other branch of the engineering profession. One noteworthy feature is that a negative line of treatment was pursued, for instead of attempting to draw up a specification of the methods to be adopted for attaining success, Mr. Swinburne spoke about a few of the difficulties in the way.

Educational Equipment, and how to get it.—"The first difficulty," he said, "is to know what equipment is necessary, and how to get it." The question here presented, is one for which it is not easy to find an answer, for the young engineer cannot predict the nature of the precise groove into which his future course of work will lead him. This view was illustrated by the remarks that a man who has made a speciality of electric waves may get his first appointment as an inspector of electricity meters; and again, that an engineer who has made himself proficient in the use of differential equations, and in the analysis of the rare earths, may find his life's work in the design of sewage plant. The best answer to the question is that "each man should have a general knowledge of applied physics and chemistry and mathematics, and a special knowledge of one or two subjects." Possibly the special knowledge may never be required, but, on the other hand, it may be invaluable. A second great difficulty mentioned by Mr. Swinburne "is to keep knowledge in a polished state ready for immediate use." His hearers were reminded that although an engineer ought to be well up in mathematics, he may only require to make use of the higher branches of that science once in several years. This is quite true, and the idea applies to other forms of educational equipment. The main thing is to acquire sufficient familiarity with such broad fundamental principles which assist their possessor to refresh old and to acquire new knowledge.

Practical Science Teachers Wanted.—Although saying that technical education was a matter not for him to discuss, Mr. Swinburne made some very trenchant and not altogether undeserved criticisms of science teachers in this country. Referring to the evolution towards the impractical that is always going on in science and technical training, he made the following remarks:—

"Science, for which no use has been found, or which is not applied, is called 'pure science,' whereas it is really the raw material, and should be called 'raw' or 'crude science.' There is an assumption of superiority in the term 'pure science,' and generally the term 'science' is appropriated by workers in raw science in much the same way as the term 'working-man' is appropriated to the exclusion of brain-workers. There is supposed to be something noble and

superior about 'raw science,' and its study is treated as the unselfish devotion to the interests of man, which is obviously entirely the wrong way round. The so-called 'scientific man' thinks that engineers and manufacturers are ignorant and unscientific, and that their practical knowledge is of no account; and that the cure for all industrial evils is more technical education, more universities, and more power to the science masters. Though there are in existence a few really practical science teachers, they are rare."

There is unfortunately too much truth in this criticism. Engineers in extensive practice cannot spare the time to become teachers, and teachers have no opportunity of gaining practical experience. Hence teaching has become academic and unpractical, and teachers have become members of a separate profession, which is more or less antagonistic to the development of scientific industries.

The Importance of Business Ability.—The science teacher is apt to look down with contempt upon the practical engineer as an ignorant man using empirical and rule-of-thumb methods, and the engineer in turn looks down on the business man as one pursuing sordid objects. In the opinion of Mr. Swinburne this is all topsy-turvy, the proper order being "the business man at the top, the practical engineer in the middle, and the unpractical engineer or the raw scientist at the bottom." So far as "getting on" is concerned this aspect of the case is quite correct. In engineering practice those who make the most money have the most business aptitude. Among successful consulting engineers text-book science is of infinitesimal value, as compared with a capacity for dealing with the main features of extensive schemes or important structural works in a comprehensive manner. To illustrate this point we may mention the remark made concerning one of the most eminent consulting engineers of the present day, to the effect that he was successful because he might be considered a good business man rather than an engineer, and that as he had in his office several thoroughly competent engineers, there was no occasion for him to exercise technical ability in matters of detail. Still it must not be assumed that text-book science is not of great value, and we are glad to note that Mr. Swinburne expressed due appreciation of scientific knowledge to all engineers. His main point in this part of the address was that "most of us suffer from too little common sense in proportion to our scientific knowledge." The lack of business capacity is a difficulty in the way of "getting on," and creates a wide distinction between the man who can earn a few hundreds a year and the man who earns as many thousands. In answer to the inevitable question, "How are we to get business and commercial knowledge?" Mr. Swinburne had practically nothing to say, apparently being satisfied to point out its importance, and to leave to each of his hearers the task of fighting his own way to the desired goal.

The Difficulty of Finding Openings.—As we remarked at the beginning of this article the chief difficulty in the way of the aspirant is to find a good opening, especially in the overcrowded state of the engineering profession. Mr. Swinburne was unable to do more in connection with this part of his subject than to indicate various difficulties to be faced. He showed, for instance, that the market value of technical knowledge has fallen owing to the modern extension of education, and that for this reason unremunerative appointments are less frequent than was formerly the case. The author showed that at the present day there is not much opening in electrical machine design, which was considered high-grade work in former days, and that there are many candidates for every opening in central station work, which is not very well paid. As for young men who go in for installation work, which was described as "electrical plumbing under an unnecessarily imposing name," Mr. Swinburne humorously remarked: "There are a great many of them, and they seem to spend most of their time going into and out of partnership with one another, like ions, and sending notices round to that effect. At other times they go bankrupt, and send no notices." As for the teaching profession, he stated that the upper grades were well paid, affording time and facility for original research, "which is a luxury, and brings reputation;" moreover, he added, "a

steady income with no expenses is a very blessed thing."

The Uses of Adversity.—Admitting that his enunciation of difficulties might seem very discouraging, Mr. Swinburne expressed the belief that it would not discourage anyone worth his salt, which is no doubt perfectly true. It is most excellent from a theoretical standpoint that beginners should have to struggle with adversity, so as to get so proficient in the art of overcoming difficulties that they can afterwards deal with them by the mere force of habit. Mr. Swinburne said: "There is nothing worse for a young man than to have about £200 a year of his own." This is merely an opinion, and we know several young people who think £100 a year would be far worse, and consider that a private income of £500 a year should be a minimum. Mr. Swinburne evidently does not believe in any adventitious aid of the kind, and he advised those of his audience who possessed this sort of private means to "go into partnership in installation work for a year or two, and then begin his business seriously," presumably after having got rid of his sordid wealth. It is written that, when somewhat similar advice as to the disposal of his property was given to a young man ages ago, "he went away sorrowful;" and if none of Mr. Swinburne's hearers went away in the same frame of mind, it may be attributed to the fact that they were sufficiently imbued with "business and commercial knowledge" to treat the advice as a purely humorous suggestion.

Municipal Expenditure.

SINCE the great outcry which took place a year or two ago comparatively little comment has been made upon municipal prodigality. Ratepayers seem to have subsided into a state of helpless apathy, and the various local authorities pursue their career of lavish expenditure with unabated energy. The position grows more serious month by month, and as one speaker remarked at the recent meeting of the Institute of Bankers, the market is flooded with Corporation stock. Capitalists are no longer anxious to invest their money on such security, with the result that county, borough, and district councils cannot raise money on the easy terms formerly prevailing, while in numerous cases they have been obliged to obtain it by overdrafts from banking companies at high rates of interest. Investors are distinctly distrustful, and the banks are now beginning to feel alarmed. It is really high time for the general body of the community to awaken to the serious position of things, and to take action with the object of curbing the ambition of local authorities to squander ready money, as well as that raised on the credit of the ratepayers, in reckless extravagance. How gloomy is the actual financial outlook may be gathered from the fact that, according to the statistics of the Local Government Board, local indebtedness has increased from £92,820,000 in 1875 to £343,416,000 in 1902. The liabilities of London already amount to more than £100,000,000, or two and a-half times the rateable value, and this enormous sum is being largely increased by the various ambitious and unjustifiably costly projects of the County Council. The baleful influence of that body seems to have spread throughout the metropolitan district. The Middlesex County Council has embarked upon vast expenditure in the direction of tramway and light railway construction, the new borough councils are all trying to live up to their new dignity, and outlying district councils are spending huge sums in all the unremunerative undertakings they can think of.

We wish it to be clearly understood that we have no objection to legitimate expenditure upon municipal works essential or desirable for the health and welfare of old and new communities. Systems of water supply, sewage disposal, drainage, and other sanitary works, improved methods of road construction, institutions for the care of the sick and needy, and schools for the instruction of the growing generation, are worthy and legitimate objects for the expenditure of public funds. But even upon such undertakings as these the municipalities have wasted much

money in consequence of the desire to render the works more ostentatious than useful, of illegitimate pandering to the pernicious doctrines of trades unionism, and of inefficient control over outgoings. Apart from justifiable enterprise, the municipalities have done much to account for the existing depression of trade by embarking in all sorts of unremunerative outlay. The erection of unnecessarily gorgeous council halls, town halls, and district council buildings, ministers chiefly to the glorification of councillors and officials, and cannot be justified for a moment, even if it be admitted that good value has been obtained for the capital invested. But the money spent on such objects is far less in amount than that dropped into the bottomless pit of electric lighting, tramway, and other unremunerative trading enterprises. Although a town hall may cost £100,000, it will last for many years, and when once built it does not eat up more money than is required for maintenance and repair. On the other hand, trading concerns under municipal management are almost invariably so unsuccessful as to constitute a heavy annual drain upon the pockets of the ratepayers. Speaking in general terms, then, it may fairly be argued that the various municipal bodies, large and small, have absorbed, and still continue to absorb, so large a proportion of the available capital of the country in unremunerative directions as to establish a serious obstacle in the way of legitimate industrial development.

Magnetic-Flux Distribution in Toothed-Core Armatures.

THE paper read to the Institution of Electrical Engineers on Nov. 24th, by Prof. Hele-Shaw, Dr. Alfred Hay, and Mr. P. H. Powell, describes a very interesting application of a hydrodynamical method of investigation to the problem of the magnetic-flux distribution in toothed-core armatures. At first sight it may not seem valid to apply the laws of hydrodynamics to a purely magnetic problem, but hesitation on this ground disappears when it is remembered that the laws governing the distribution of magnetic flux in space of two dimensions are identical with those which apply to the stream-line motion of a perfect incompressible fluid in two-dimensional space. This being so, it is readily seen that by causing such a fluid to flow between parallel bounding-walls we will obtain a definite distribution of stream-lines which, if photographed, will give us a picture of the magnetic lines or tubes in a corresponding two-dimensional magnetic problem. This is the principle underlying the hydrodynamical experiments described in the paper by the three authors abovenamed.

In the practical application of this principle one great difficulty is to find some hydrodynamical analogue for magnetic permeability, as otherwise we should be confined to examples of magnetic distribution in uniform media; but the authors show that when dealing with a viscous liquid flowing in thin parallel layers we may, by varying the thickness of the layer, obtain results exactly analogous to the effects of permeability in a magnetic medium—the permeability varying as the cube of the thickness of the liquid layer. Working on this basis the authors have taken photographs of stream-lines in the flow of glycerine in thin layers between parallel walls of plate-glass, the models being so constructed as to represent the magnetic lines from the pole-piece of a dynamo across the air-gap and into a toothed-core armature. These photographs are very instructive and very useful in the solution of problems on magnetic-flux distribution. Take, for example, the flux-distribution produced by the armature-teeth. The presence of teeth is, in effect, equivalent to an increase in the length of the air-gap, and by multiplying the actual air-gap by a "correction coefficient" we may then proceed with the calculations as if there were no teeth and the distribution were uniform. This "correction coefficient" can be ascertained at once from the diagrams of the stream-lines, as it is equal to the number of stream-lines per unit length in the space well under cover of a tooth, divided by

the mean number of stream-lines per unit length for tooth and slot. The authors give a table of values of this coefficient for different values of the two ratios upon which it depends, viz., s/t and s/g, where s = width of slot, t = width of tooth (at bottom), and g = length of gap; and the agreement between the values thus obtained and those obtained by Mr. F. W. Carter by a process of calculation is very noteworthy.

The second part of the authors' investigation, which deals with the reluctance of the teeth themselves, does not admit of the application of the stream-line method, but the electromagnetic method employed is very interesting, and the results obtained are of considerable importance with regard to dynamo design. Reference to the paper itself will satisfy the reader on this point; here we only desire to draw attention to the beauty and interest of the stream-line method of analysis used by the authors for the elucidation of these difficult magnetic problems. The illustrations accompanying the paper—reproductions of photographs—are extremely good, and many useful lessons can be learned from them by simple inspection. We hope further applications of this method of investigation may soon be made.

The Cost of Production.

In the recent presidential address to the members of the Institution of Electrical Engineers, Mr. Alexander Siemens adopted the useful course of selecting a subject full of practical interest to his audience, and one upon which his long connection with industrial engineering gives him exceptional qualifications for treating in an adequate manner. Starting with the assumption "that the true foundation of modern civilisation is the lowering of the cost of production," he showed that the progress of civilisation was in proportion to the cheapening of articles of consumption. Not only in the electrical, but in all other branches of industry, continued progress certainly appears to depend very largely upon further reduction in the cost of manufactures. The means available for the attainment of that end are various. New methods of production, improved systems of management, and fresh types of design, are important features for consideration; and if the working man will only be willing to recognise the truth of the principle that increased and more economical production is for his own benefit, as well as for that of his employer and of his fellow-countrymen generally, there is no doubt that very material progress can be made in the direction indicated. Mr. Siemens stated that for "internal working" every industry depended upon three main factors: the capital, the workmen, and the management.

Capital.—Dealing with capital first, he demonstrated that its share in the value of the finished article was proportionate to the cost of the depreciation and the maintenance of the works and of their outfit, to the cost of the raw materials, and to the profit representing interest on the amount invested. It is clear that to keep the item of depreciation within proper limits, the works and equipment should be so designed as to give the maximum output with a minimum amount of wear and tear. The cost of raw material, being generally the finished product of some other branch of industry, cannot be regulated to any considerable extent by the purchaser, although the general adoption of means for reducing the cost of production will have an appreciable effect upon this item. So far as the third item is concerned, there is, as Mr. Siemens remarked, very little difficulty in reducing the ratio, but it must not be forgotten that the profits distributed to capitalists must not be too far diminished, otherwise the industry in question may be injuriously affected.

Workmen.—Discussing the second main factor, Mr. Siemens adopted a line of argument that deserves the earnest consideration of all workmen who desire to look at things fairly and squarely. Men of this indispensable class will do well to learn that the amount of work turned out in a given time has a twofold influence on the

result, because the time occupied in producing an article not only regulates the amount of the wages payable, but also the percentage of the dead charges to be paid per unit of production. They should also realise that while the legitimate object of the employer is to reduce the amount paid in wages for any given article, this object is quite consistent with the increase of wages earned by the workmen themselves. Experience abundantly demonstrated the fact that the introduction of improved machinery does not render skilled labour superfluous, but on the contrary leads to the employment of more workmen at better wages than before. Moreover, improved labour-saving machinery relieves the men of much purely animal effort, and makes it possible for them to occupy their hours of recreation to better advantage and with greater enjoyment. Adverting to restriction of output, whose practice is so strongly favoured by trades unions, and whose existence is as strongly denied by them, Mr. Siemens showed that the general effect was exactly the opposite of that intended. Thus, assuming the price of a certain product to be raised owing to this advocated remedy for shortness of employment, large numbers of consumers begin to do without it, thereby leading to a reduced demand and consequent lack of employment. In mentioning another fetich of the working man—the demoralising theory that all workmen should be treated alike—Mr. Siemens narrated a personal experience of the disastrous effect of this policy. Twenty-five years ago he erected at Leeds the first continuous glass furnace for bottle making, which avoided many difficulties of the old method, and with which the secretary of the trade union, who worked at the furnace, expressed his great satisfaction. Though prices were lowered the men earned more money, but when the owners wished to put up more furnaces of the same kind the union threatened to withdraw all its members, the explanation being that they did not wish to see some of their men working under better conditions than others. To this decision the union adhered for nearly twenty years, and in consequence scarcely any glass bottles were now made in England.

In commenting on this part of the address one of our contemporaries says "the workman is not so unreasonable as we are apt to believe." We are inclined to agree with this remark. The workman himself is not the chief offender. He would act far more reasonably than he now does if allowed to do so by the "Vehmgerichte" which he has established under the name of the trades union. Large numbers of workmen disagree with the irrational and arbitrary proceedings of this egregious body, but they are powerless.

Management.—With regard to management, Mr. Siemens discussed only the influence of design in reducing cost of production, pointing out the desirability of using standard sizes and the advantage of designing new work in such a way that the difficulties of manufacture should be reduced to a minimum. Happily we have seen a great improvement of recent years in manufacturing methods. Old-fashioned and time-worn machinery has been displaced by modern appliances, and many badly-arranged works, representing the accretion of generations, have been swept away in favour of well-arranged modern buildings. But even the erection of the most approved premises and the installation of the most efficient plant will be of comparatively little use unless assisted by the organisation of a carefully thought-out system of management, and, above all, by the cordial co-operation of those representing capital on the one hand and labour on the other.

External Factors.—The metric system, which was discussed at some length by the President, is less important as an aid to reducing the cost of production than as a factor influencing the advancement of commerce. The subject is one of controversial character upon which engineers are by no means in agreement, and the compulsory adoption of the metric system is not likely to be realised in the immediate future, however desirable may be its intrinsic merits. Passing on to discuss the question of patents, Mr. Siemens contended that the value of a preliminary examination as practised in the United

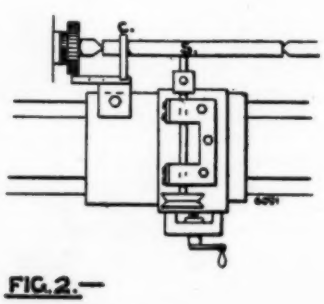
States had been somewhat exaggerated. He thought it involved as much trouble as a lawsuit, and was no bar to the commencement of a lawsuit later on involving the re-argument of the case. He admitted, however, the value of the American system for the detection of anticipations. While dealing with this part of his subject the President gave the exceedingly practical advice that it was an extremely risky thing for business firms to purchase patents for inventions, which, at the present rate of progress and change, might very soon become worthless, and that the royalty system was in every way safer, as well as being more equitable for both parties concerned.

Finally, Mr. Siemens remarked, in connection with proposals to protect British industries against foreign competition, that two points required particular attention, one that it was hopeless to re-establish our former monopoly, and the other that it would be useful to inquire whether our former industrial supremacy had not led to neglect in many respects, for which we were now suffering. This portion of the general subject doubtless presented a strong temptation to embark upon a discussion of fiscal policy. As this is another subject of highly controversial character, we think the speaker was wise in resisting the temptation. Whatever remedies may be adopted for enabling British industries to hold their own against both fair and unfair competition, it is undoubtedly the fact that they will be very materially aided by well-directed efforts to reduce the cost of production for the benefit of the whole community.

Lathe used to Mill Spiral Grooves.

During the building of a special machine it was necessary to devise a means of milling a series of spiral grooves, of the shape shown at Fig. 1, in a shaft *S* of $\frac{3}{4}$ in. diameter. The grooves were about $2\frac{1}{4}$ ins. long, $\frac{5}{16}$ in. wide, and $\frac{1}{16}$ in. deep. The only machine-tool available was a screw-cutting lathe, to which was attached the arrangement shown in the illustration (Fig. 2). This consisted of an L-shaped cast-iron bracket (Fig. 3) bolted to the lathe carriage, the contour of the vertical leg of bracket coinciding with the groove form (Fig. 1). A special carrier *C*, having a long leg, was attached to the spindle and kept tight against the profiling bracket, the feed being then operated in a longitudinal direction. The milling cutter, carried in a bracket, as shown, was driven direct from an overhead pulley temporarily fixed and driven from the main shaft. Some little amount of experimenting was necessary before getting the correct result, but we finally obtained a very satisfactory job.

W. E. G.



MILLING SPIRAL GROOVES.

The Design of Fly-wheels.

By A. H. GIBSON, B.Sc.

CONSIDERING the importance of the subject, the fly-wheel receives very scant attention by those concerned with, or in most of the books devoted to, the design of the steam-engine. Now although all engineers agree that the fly-wheel is a nuisance—unfortunately a necessary nuisance—there is no need to make it a bigger, or a heavier, or a more dangerous nuisance than is absolutely necessary; and in this article, the author intends to attempt to consider the design and construction of fly-wheels, showing the conditions which they must fulfil under certain circumstances, and the suitability of various designs for fulfilling these conditions.

In the first place as to the function of a fly-wheel.

In any engine, the turning effort on the crank-shaft varies with the angle turned through by the crank, for various reasons—the steam pressure on the piston varies throughout the stroke—the angle between the crank and connecting rod varies, so that the effective arm of the thrust of the connecting rod varies, and the inertia of the moving parts, together with their weight, all tend to cause a variation in the angular velocity of the crank shaft, which variation is cyclic, that is recurring, each stroke.

This fluctuation of velocity we shall call the primary fluctuation.

Then again the pressure of the supply steam may vary; and also the resisting moment of the load, as applied to the crank shaft, will vary from time to time as more load is thrown on or off, and this variation in the case of an engine driving a rolling mill, or driving a tramways load, may be exceedingly rapid, practically the whole load being thrown on or off almost instantaneously. This variation—which is not cyclic—causes a fluctuation in the angular velocity of the crank shaft, which we shall call the secondary fluctuation, and which is much more important than the primary.

In the steam-engine we have two pieces of mechanism, each of which in its own way tends to reduce the magnitude of these fluctuations—the governor and the fly-wheel. From the nature of the governor, it is obvious that, before any regulating action can be called into play, the speed of the engine must have already increased; and it is also obvious that, since the governor acts by cutting off or throttling the supply of working fluid, it is quite unable to prevent any fluctuation which may take place, due, say to load being thrown off after the point of cut-off in any stroke, until the next stroke. The governor thus takes care within certain limits, of the fluctuation from stroke to stroke, but does not affect the primary fluctuations, which, along with such a fluctuation as just stated, are left to be regulated by the fly-wheel.

This regulation is accomplished, by the fly-wheel having its angular velocity, and hence its kinetic energy increased, when the power being developed is in excess of that being absorbed by the resisting moment on the crank-shaft; and by again giving out this store of kinetic energy, and hence, having its angular velocity diminished, when the demand for work at the crank-shaft is greater than the supply at the engine-cylinders.

Evidently, then, some fluctuation in velocity is here again necessary for the alternate storing and giving out of energy by the fly-wheel; and we shall now consider the magnitude of this necessary fluctuation, and the conditions under which it may be kept within any required limits.

And firstly, as we shall be continually using the terms kinetic energy and moment of inertia, it would be well to deduce the connection between the two. If w lbs. is the weight of any small particle of matter, whose centre of gravity is moving

with a velocity of v ft. per second, then the kinetic energy of the particle is said to be $\frac{1}{2}\frac{W}{g}v^2$ ft.-lb. units of energy, g being the acceleration of gravity—32 ft. per second. If now a wheel be considered as being built up of a series of such particles, all of which are describing angles at the same rate, round the centre of the wheel, that is, all of which have the same angular velocity w, then, since the linear velocity of any particle at a distance r, from the centre of rotation is $r\,w$, the kinetic energy of such a particle will be $\frac{1}{2}\frac{W}{g}w^2r^2$. So that the kinetic energy of the whole wheel will be equal to the sum of all such terms as $\frac{1}{2}\frac{W}{g}w^2r^2$, taken over all the wheel, *i.e.* $\frac{w^2}{2g}\Sigma Wr^2$, where the sign Σ, simply means the sum of all such terms as follow the sign. As w and g are constant in any wheel for every particle of the wheel, the term $\frac{w^2}{2g}$ will be common to every particle, and hence may be taken outside the Σ.

But the quantity $\frac{W}{g}\cdot r^2$ is called the moment of inertia—I—of the particle of weight w lbs., and at a distance r feet from the axis of rotation of the wheel, so that the whole moment of inertia of the wheel is represented by $\Sigma\frac{W}{g}r^2 = \frac{1}{g}\Sigma Wr^2$

Finally then we have :—

Kinetic energy $= \frac{1}{2}w^2 \times$ Moment of Inertia,
or, $KE = \frac{1}{2}Iw^2$.

The value of I varies with the form of the fly-wheel. In the case of a disc fly-wheel of radius R ft. and of weight W lbs., the moment of inertia is $\frac{W}{g} \times \frac{R^2}{2}$.

In the case of a fly-wheel of the ordinary type, having a rim of internal radius R_1 and of external radius R_2 ft. and of weight W lbs., the I of the rim would be—

$$\frac{W}{g}\cdot\frac{R_1^2 + R_2^2}{2}$$

in ft.-lb. units. In addition to this we have the moment of inertia of the arms, hub, and fly-wheel shaft, all of which act as storers of energy, but in general these are of small importance in comparison with the rim and may safely be neglected, especially as the error thus brought in to the calculations is on the right side, and tends to make the fluctuation of velocity slightly less than calculated.

We can make a very close approximation however to the accurate value of the moment of inertia of the whole rotating system of wheel and shaft, by assuming the arms to have all their material concentrated at their middle points. If the total weight of the arms is W_3, and if the radius of their middle points is R_3, then the I of the arms is $\frac{W_3}{g}\cdot R_3^2$. Again, taking the hub as being a solid disc of its own radius R_4 and weight W_4, its I will be $\frac{W_4}{g}R_4^2$, while the I of the shaft of radius R_5 and weight W_5 will be $\frac{W_5}{g}R_5^2$. Adding we get the moment of inertia of the whole system.

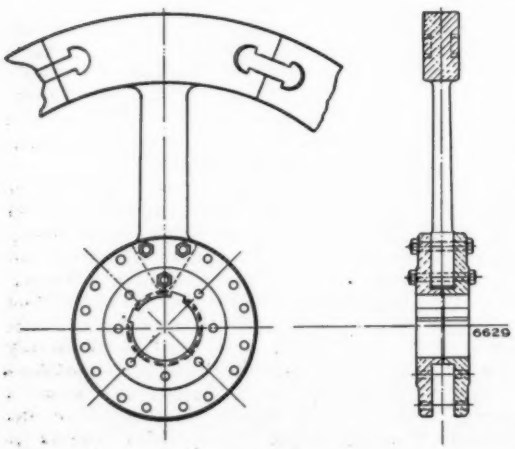


FIG. 7.

In the case of the wheel, illustrated in Fig. 7, which is running on a rolling-mill engine, and has specially heavy arms, we get—

I of rim alone	=	50·2	foot-ton units.
I of arms	=	3·8	,, ,,
I of hub	=	·37	,, ,,
I of shaft	=	·43	,, ,,
so that I of whole	=	54·8	,, ,,

The percentage error, then, in neglecting the arms, hub, and shaft, in this case, is 9·6, a percentage which is somewhat serious in the case of a very heavy wheel.

Next, to consider the amount of the cyclic primary fluctuations.

Let W = weight of reciprocating parts, in lbs.
,, W_1 = weight of revolving parts, flywheel, etc., when resolved into their equivalent on the crank-pin radius, that is, a weight W at a radius R, will be replaced by a weight $W\frac{R^2}{r^2}$ on the crank-pin radius r.
,, w_0 = mean angular velocity through the revolution = $\frac{2\pi}{n}$, where 2π is the angle turned through (in radians) per revolution, and where n is the number of revolutions per second.
,, M = turning moment on crank shaft, due to steam pressure.
,, R = turning moment on crank shaft, due to resistance applied by the load (supposed steady at present).
,, t = time which has elapsed in seconds, since the beginning of the stroke.

Now, if Fig. 1 represent diagramatically the engine under consideration, the angle turned through by the crank will be $w_0 t$, and the velocity of the piston line in the position shown, neglecting the obliquity of the connecting-rod, will be equal to $\left(\text{velocity of crank-pin} \times \frac{W_1 N}{r}\right) = w\,r \sin(w_0 t)$, so that kinetic energy of rotating and reciprocating parts—

$$= \tfrac{1}{2}\frac{W_1}{g} w^2 r^2 + \tfrac{1}{2}\frac{W}{g} w^2 r^2 \sin^2(w_0 t),$$

or, putting $\frac{W_1 r^2}{g} = I$, and $\frac{Wr^2}{g} = I$, we get

$$KE = \tfrac{1}{2}[I_1 w^2 + I w^2 \sin^2(w_0 t)].$$

Differentiating, this with respect to $w_0 t$ gives the rate of change of KE, with respect to the angle turned through. But the change of KE must always be equal to the difference between the work done on, and the work done by the moving parts, and as the work done by a turning moment equals the moment, multiplied by the angle turned through, in radians, we get

$$\frac{d[\frac{1}{2}(I_1 w^2 + I w^2 \sin^2 w_0 t)]}{d(w_0 t)} = M - R + Wr \sin(w_0 t).$$

The last term $[Wr \sin(w_0 t)]$, being due to the effect of the weight of the

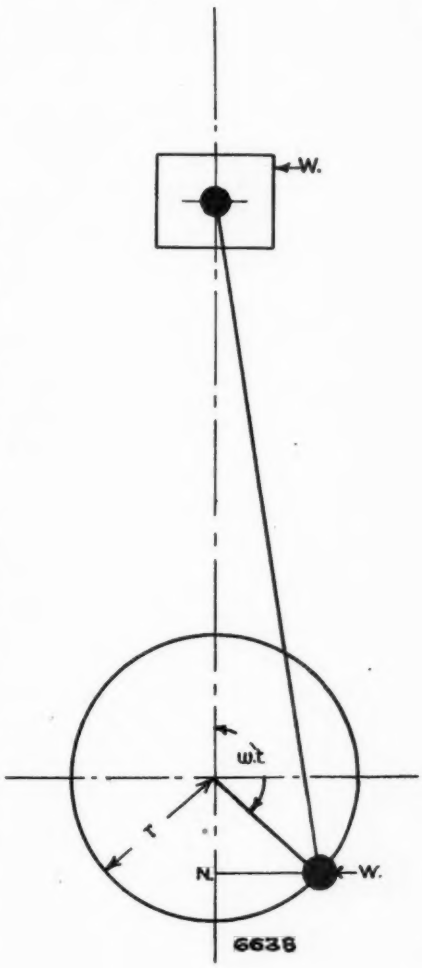


FIG. 1

reciprocating parts, is only needed when dealing with vertical engines.

As the cyclic variations due to—

(1) the inertia of the moving parts,
(2) the varying moment of steam pressure on crank,
(3) the effect of weight of reciprocating parts

are severally small, we may calculate these as if each were independent of the others, and superpose them to get the total fluctuation.

(1) Variations due to inertia. Neglecting the steam pressure, and the weight of the piston line, we see that as no work is done on or by the moving parts, their KE is constant, the angular velocity of the crank varying, so that at the ends of the stroke, when the velocity of the piston line is zero, the velocity of the rotating parts is a maximum, while at the middle of the stroke, when the velocity of the reciprocating parts is a maximum, the velocity of the rotating parts is a minimum.

Expressing the fact that the KE is constant, we get—

$$\frac{w^2}{2}\left[I_1 + I\sin^2(w_0 t)\right] = C^2.$$

$$\therefore w = \frac{C}{\sqrt{\frac{1}{2}\left[I_1 + I\sin^2(w_0 t)\right]}}$$

$\therefore w$ is a maximum when $t = 0$ or $\frac{\pi}{w_0}$ and then is equal to $\frac{C}{\sqrt{\frac{1}{2}I_1}}$, since $\sin w_0 t$ then $= 0$, and w is a minimum when $t = \frac{\pi}{2w_0}$ or $\frac{3\pi}{2w_0}$, and then equals $\frac{C}{\sqrt{\frac{1}{2}(I_1 + I)}}$, since $\sin w_0 t$ then equals unity.

Thus we have—

$$\frac{w \text{ max.}}{w \text{ min.}} = \sqrt{\frac{I_1 + I}{I_1}} = 1 + \tfrac{1}{2}\frac{I}{I_1} \text{ (approximately).}$$

Let $w = w_0(1 + a^2 \cos 2w_0 t)$. This satisfies the condition that the angular velocity should be a maximum, when $t = 0$ or $\frac{\pi}{w_0}$, $\cos 2w_0 t$ then being equal to $+1$, and that the angular velocity should be a minimum when—

$t = \frac{\pi}{2w_0}$ or $\frac{3\pi}{2w_0}$, $\cos 2w_0 t$ then being equal to -1.

Then $\frac{w \text{ max.}}{w \text{ min.}} = \frac{1 + a^2}{1 - a^2} = 1 + 2a^2$ (approximate).

So that $1 + 2a^2 = 1 + \frac{1}{2}\frac{I}{I_1}$

$$\therefore a^2 = \tfrac{1}{4}\frac{I}{I_1}$$

$$\therefore w = w_0\left(1 + \tfrac{1}{4}\frac{I}{I_1}\cos 2w_0 t\right)$$

(2) Variations due to varying moment of steam pressure. Here we assume that the turning effort required to overcome the resistance due to the load is constant and equal to R foot lbs. Fig. 2 then represents the crank-effort diagram, drawn in the usual way, for a single-cylinder engine, the inertia effect of the reciprocating parts being neglected. The curve is plotted with angles turned through by

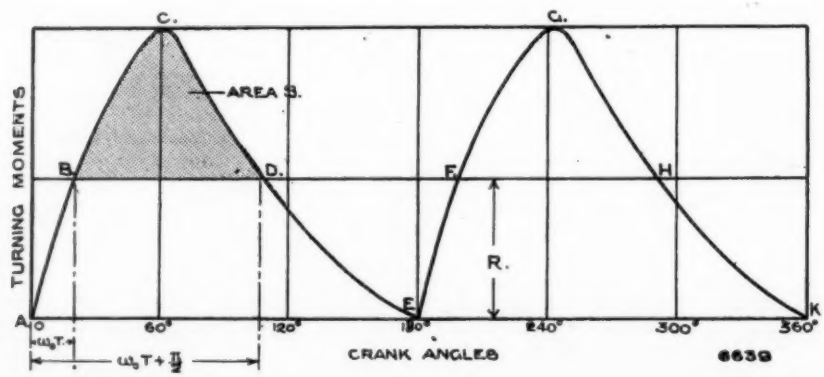


FIG. 2.

the crank as abscissae, and with turning moments in foot lbs. as ordinates. Evidently from A to B, the work done by the steam is less than that being absorbed at the crank-shaft, so that the velocity must be diminishing. At B the moment exerted by the steam pressure is equal to that exerted by the resistance at the crank-shaft, and from B to D, the work done by the steam is in excess of the work absorbed at the crank-shaft, so that the speed increases from B to D, until the increased KE of the rotating parts is equal to the work represented in foot lbs., by the area B, C, D, on the crank-effort diagram. From D to F again the speed diminishes, until the loss of KE by the rotating parts, equals the work represented by the area D, E, F. Evidently, then, the velocity will be a maximum at D and H, and a minimum at B and F. If the area $B\ C\ D$ represent S foot lbs. of work, we get then

$$\frac{d}{d(w_0 t)}\left[\frac{I_1 w^2}{2}\right] = M - R,$$

neglecting reciprocating parts.

And, therefore, integrating between the limits B and D, we get

$$\frac{I_1}{2}(w_D^2 - w_B^2) = S,$$

the integral of $M - R$, between the limits B and D, being of course represented by the area $B\ C\ D$.

$$\therefore w \text{ max.}^2 - w \text{ min.}^2 = \frac{2S}{I_1}.$$

Now it will be generally found that the distance from B to D is very approximately equal to $\frac{\pi}{2}$ measured on the base line, so that we may let

$$w = w_0 [1 - a^2 \cos 2w_0 (t_1 - \tau)];$$

t_1 being the angle turned through by the crank.

Thus when $t_1 = \tau$, *i.e.*, the crank is in a position corresponding to B, the vel. $= w_0 (1 - a^2)$, which is a minimum value of w, while when $t_1 \left(\tau + \frac{\pi}{2w_0}\right)$, *i.e.* the crank is in a position corresponding to D, the vel. $= w_0 (1 + a^2)$, a maximum value of w.

$$\text{So that } \frac{w \text{ max.}}{w \text{ min.}} = \frac{1 + a^2}{1 - a^2}$$

$$\therefore \frac{w \text{ max.}^2}{w \text{ min.}^2} = \frac{1 + 2a^2}{1 - 2a^2} \text{ (approximate)},$$

$$\therefore w \text{ max.}^2 - w \text{ min.}^2 = w_0^2 (4a^2) = \frac{2S}{I_1}$$

$$\therefore a^2 = \frac{S}{2I_1 w_0^2}$$

$$\therefore w = w_0 \left[1 - \frac{S}{2I_1 w_0^2} \cos 2w_0 (t_1 - \tau)\right].$$

In the case of a vertical engine, we shall also have the fluctuations in speed due to the fact that the turning moment on the crank-shaft, due to the weight of the reciprocating parts, varies with the crank angle, the moment, in the crank position shown in Fig. 2, being Wr sin $w_0 t$.

So that, assuming the increase of kinetic energy to be given entirely to the rotating parts, we get on differentiating with respect to $w_0 t$.

$$\frac{d}{d(w_0 t)}\left[\frac{I_1 w^2}{2}\right] = Wr \sin (w_0 t)$$

$$\therefore \frac{I_1 w^2}{2} = C - Wr \cos. (w_0 t)$$

$$\therefore \frac{w \text{ max.}}{w \text{ min.}} = \sqrt{\frac{C + Wr}{C - Wr}} = \frac{1 + \frac{1}{2}\frac{Wr}{C}}{1 - \frac{1}{2}\frac{Wr}{C}}$$

(Approximately).

Evidently w is a maximum when $w_0 t = \pi$, and is a minimum when $w_0 t = 0$ or 2π.

Let $w = w_0 [1 - a^2 \cos (w_0 t)]$. This expression satisfies the required conditions, and we get—

$$\frac{w \text{ max.}}{w \text{ min.}} = \frac{1 + a^2}{1 - a^2}, \text{ so that } \frac{1}{2}\frac{Wr}{C} = a^2$$

But when $t = \frac{\pi}{2w_0}$, the angular velocity will be very approximately equal to w_0, so that we get—

$$\frac{I_1 w_0^2}{2} = C$$

$$\therefore a^2 = \frac{\frac{1}{2} Wr}{\frac{I_1 w_0^2}{2}} = \frac{Wr}{I_1 w_0^2}$$

Adding for the total variation of angular velocity we get :—

$$w = w_0 \left[1 + \frac{1}{4}\frac{I}{I_1} \cos. 2w_0 t - \frac{S}{2I_1 w_0^2} \cos. 2w_0 (t_1 - \tau) - \frac{Wr}{I_1 w_0^2} \cos. (w_0 t)\right]$$

The most convenient method of recording these results is to calculate the values

of the fluctuations due to these three causes separately, for different values of $w_0 t$ from 0 to 2π, and plot the three curves separately on the same crank-angle base. Then, by adding the ordinates of the three curves, the total fluctuation curve may be plotted.

In the case of a side-by-side engine, having cranks at right-angles, the crank-effort diagram becomes as shown in Fig. 4, and evidently S, the amount of work to be absorbed—in this case per half stroke—due to inequality of turning moment is evidently much less than in the preceding case, and in general too, owing to the fact that the cranks are at right-angles, the effect of the inertia of the moving parts will be negligible, so far as it results in causing fluctuations of velocity. As, in general, the effect of the weight of the moving parts is small, we may in this case neglect everything except the variation in the turning moment when the engine is running steadily.

Noticing that the resultant crank-effort diagram crosses the line of mean resisting moment at intervals of approximately 45 degs., then, using the same notation as used in Fig. 2, we get that

$$w = w_0 \left[1 - \frac{S}{2I_1 w_0^2} \cos. 4w_0 (t - \tau \right]$$

If, now, the whole of the load be thrown off the engine suddenly, just after the point of cut-off, this will be the most severe test of the regulating capacity of the fly-wheel that can be applied, and in this case the cross-hatched area in Fig. 4, as will be seen later, shows the amount of work which must be absorbed by the fly-wheel without its velocity increasing beyond the required limits.

The fly-wheel must then be so designed that the sum of the fluctuations due to the normal varying turning moment, and to this possible abnormal variation of load does not exceed the contract fluctuations.

Generally speaking, this latter variation of turning-effort due to abnormal fluctuation of load will be greater in the case of a side-by-side than with a tandem engine, though the variations in the case of steady running will be less than in a tandem or single-cylinder engine, so that, except where—as in an engine driving tramways load for example—the whole load may be thrown off at once, a much lighter fly-wheel will suffice for a cross-compound engine than for a tandem engine of the same power.

It will be noticed from the form of the result obtained for the angular velocity at different points of the stroke, that the fluctuations due to weight of the moving parts and to varying moment of steam pressures, vary inversely as the square of the angular velocity of the engine, so that these fluctuations will be much more important in a slow-speed than in a high-speed engine. On the other hand, the fluctuation due to the inertia of the moving parts is independent of the speed of rotation, and always is a fixed proportion of the mean angular velocity for the same engine.

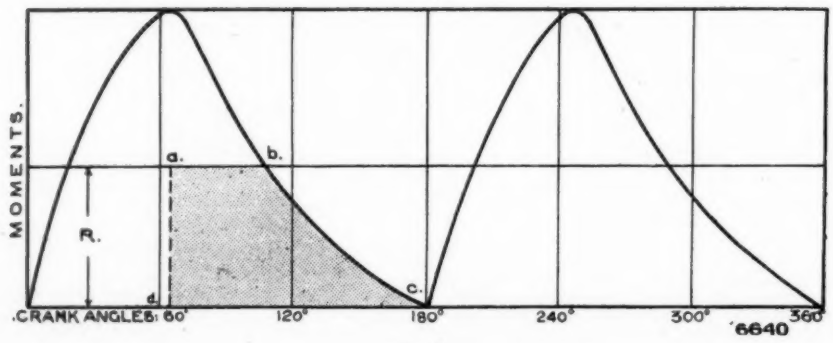


FIG. 3.

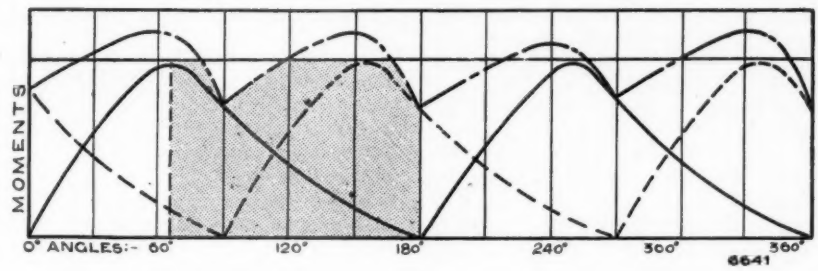


FIG. 4.

Experiments show that the fluctuations, as calculated by this method, follow very approximately the law as deduced from actual experiment; the experimental results being slightly in excess of those obtained by calculation.

These cyclical fluctuations are not of great importance in the case of a single engine driving an independent load, whether on electrical work or when driving a mechanical load; but they become important when the engines on which they occur are driving alternators which are intended to run in parallel. Here it is very important that the fluctuations occurring during each stroke, as well as those occurring from one stroke to another, should be kept within narrow limits.

Next suppose that, in addition to this cyclic variation, the whole of the load is thrown off just at the point of cut-off. This will give us the case in which the maximum possible amount of work is to be absorbed by the fly-wheel, and hence, in which the greatest fluctuation of velocity will take place; so that, if the wheel be designed so that the variation under these conditions does not exceed the maximum permissible under the contract, the variation under all other conditions of running will be easily within the proper bounds.

If, in Fig. 3, which represents the crank-effort diagram for the engine, when running on full load, *d* represents the position of the crank at the point of cut-off, then the extra work to be absorbed by the fly-wheel during that stroke, due to the sudden throwing off of the load, is represented by the area *a*, *b*, *c*, *d*. So that, if the angular velocity at the end of the stroke when running under steady conditions as to load be w_1, and if the actual velocity is w_2, and if the area *a*, *b*, *c*, *d*, represent S_1 foot-lbs. of work done on the fly-wheel, we shall have—

$$\tfrac{1}{2} I_1 [w_2^2 - w_1^2] = S_1.$$

From this we can find w_2, the maximum angular velocity, and hence $w_2 - w_0$, which must be equal to half the permissible fluctuation of velocity. Generally, $w_2 - w_0$ must be less than $2\frac{1}{2}$ per cent. of w_0, for electric-lighting engines.

In the case of an engine driving an air compressor, or a blowing engine, in which the compressor pump plunger, or the air cylinder piston, is mounted on a prolongation of the steam piston rod, the same construction as before may be used, care being taken to obtain the resultant thrust of the connecting rod on the crank for any point of the stroke, by taking the difference of the thrusts on the steam piston and on the air-cylinder piston at that point. The crank-effort diagram can then be drawn in the usual manner. In this case—as in the case of a rolling-mill engine—close governing is not essential.

The fly-wheel of a rolling-mill engine, in particular, is subjected to very rough and trying usage, as the whole of the load is thrown instantaneously on and off. In fact the function of the engine in this case, is mainly to give to the fly-wheel a large store of energy which may be almost instantaneously available.

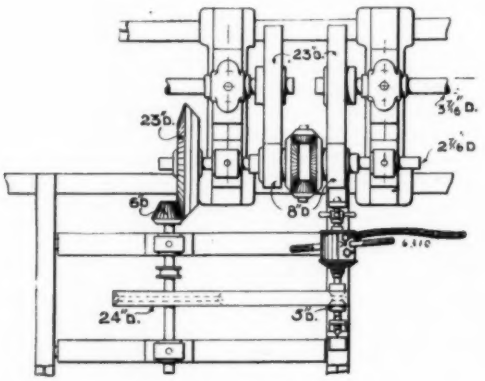
In this case the fly-wheel is of great importance, in enabling the size of engine required to drive any given rolls, to be kept within reasonable limits, as, for a short time—when an ingot is entering the rolls, it may be necessary for work to be done at twice the normal horse-power of the engine, this work being done at the expense of the accumulated energy in the fly-wheel.

It is extremely difficult to apply any theoretical reasoning to the design and weight of fly-wheel for a rolling-mill engine, on account of the general insufficiency of data,—experience being the only safe guide.

(To be concluded.)

Application of Air Drill.

A rather novel application of an air drill was made the other day. A piece of machinery for the Gold Fields having been erected in a part of the shop away from any shafting which might have been used in testing it, the difficulty arose of putting it in motion. To solve the problem, the apparatus, of which the following is a description, was rigged up. Fixed on to the $2\frac{7}{16}$ ins. diameter driving-shaft shown in plan Fig. 1, was a grooved iron pulley, 24 ins. in diameter. In the groove ran a rope driven by a wooden pulley fixed on to the spindle of an air drill. As the rope did not fulfil its purpose, owing to slackening, a belt was substituted, the grooved pulley being retained, and a piece of rope spliced tight in the groove and the belt run on top. The feed-head of the drill and the drill itself were supported by knees clamped to the supporting girders, on which the machinery was erected. The material or machinery turned weighed close on 15 tons and was composed of steel tubes bound with rings and having rolling strips for bearing on guide rollers, which were fixed to shafts indicated on sketch. The sizes of the shafting are given, also the diameters of the principal wheels. The pressure of the air used was 75 lbs. per sq. in., and the result was very successful. EUAN FLEMING.



APPLICATION OF AIR DRILL.

Gold Coast Palms.

A Neglected Source of Wealth.

By LINDSAY W. BRISTOWE.

We may well call the West African littoral a "Land of Palms," for the first impression of the coast forced on travellers is the ubiquity of the cocoanut palm.

Many of these trees are of grand proportion, rising 50 and 60 ft. sheer from the sandy soil, having a diameter at the base of from 2 to 3 ft., with a crown of long pendulous leaves forming a canopy for the sheaths of golden blossoms and clusters of huge nuts.

The cocoanut palm (*cocos Nucifera*), known to the natives as Kubeydua, though commercially of enormous value elsewhere, is put to little use on the Gold Coast. The half-pint or so of "milk" is drunk, the soft-core eaten, and only a very limited number of the nuts exported to England. A healthy tree, however, should yield at least 100 nuts per annum. These realise in the Liverpool Market say about 60*s.* or more per thousand. As there are millions of such trees, the loss to the colony by a neglect to export is obvious, even allowing for a fall in price as the result of a better supply on the home market. In Central America the annual value of a tree is placed at 10*s.* The various uses to which the cocoanuts are put are too well-known to need description in these pages.

There are several reasons why this commercial product remains undeveloped, but the drawbacks to be overcome are not insuperable. First, there is the cost and worry of acquiring these cocoanut groves, owing to sub-division of ownership; then there is the difficulty of collecting the nuts, as the groves are sometimes two or three miles apart, in fact, wherever there is a village; then there is the shipment through the furious surf, and finally the heavy rate of freight.

The first difficulty could be overcome by entering into contracts with the chiefs and people of each village to supply the nuts at so much per hundred, the contract covering a period of years. If delivery at the port of shipment was stipulated the question of collection would not arise. The natives' own fishing-canoe is admirably adapted for the purpose of shipping the nuts, and would be more economical than the cumbrous surf-boat. The question of freight would be merely a matter of arragement with the steamship company. Capital and enterprise are alone required to make the palms become a source of wealth to the colony.

However interesting the cocoanut palm may be, and however great its potential economic value on the coast, I was particularly anxious to study another palm, the "butter palm" (*Elais guineensis*), or Abeydua as the natives call it. It is found throughout Western Africa, the healthiest and best bearing trees growing in the near vicinity of streams and in the warm damp valleys. In order to ascertain all about the oil-producing area, and discover in what way it could be encouraged, and if improved communication was required to the points of shipment, I made a tour of inspection in the forest district lying between the rivers Amissah and Tarkwa. This involved a long journey by hammock with all the inconveniences of "roughing it," not to mention managing a troop of Krooboys and native followers.

A ten minutes' walk from the village which I had made my headquarters brought me into an extensive forest of oil palms. Very beautiful they looked as I saw them scattered about in charming confusion, their dark green feathery fronds revealing clusters of orange and red fruit, half embedded in sheaves, peeping from beneath the base of the leaves.

The native looks upon the matter prosaically. The palm-oil tree is a permanent source of wealth to him, and I may say

more litigation arises in connection with them than with anything else. The ownership of a solitary tree is fiercely contested. And no wonder; for the native builds his house with the leaf-stalks, thatches it with the leaves, illuminates it with the oil he extracts from the berries; every article of food he eats must have palm oil as a principal ingredient; he relishes the kernel of the berry, and finally extracts a wine from the tree, upon which he gets gloriously drunk.

NATIVE CLIMBING OIL PALM.

So bountifully has nature endowed the soil that palm trees seem to spring up as if by magic. Only in isolated cases have I come across natives who intelligently and systematically cultivate this palm, renewing old trees and extending their forests. Boundaries amongst the natives are fearful and wonderful things, often driving Judges and Commissioners to despair, although to the native the intricacies are as simple as daylight. Not a single palm raises its head out of the ground, but there is a native to claim it. With its growth he does not concern himself. Tangled with weeds, it struggles on in its upward course, and at the end of three years, if the soil is good and the elements propitious, it commences to bear fruit.

There is a fixed price for the trees among the natives. Should one neighbour by mistake cut down the tree of another, compensation to the extent of £1 a tree must be paid.

The productiveness of a palm tree and the quality of the berry are naturally dependent on the nature of the soil. Trees grown in a moist soil will give very rich berries of an orange or red hue, whilst those grown on dry soil have dark berries, poor in oil. The nut of the berry also varies in size, the one giving the largest quantity of oil has the smallest nut, whilst a large nut gives the least oil. Trees grown in the valleys may give as many as ten to twelve bunches of fruit per annum, whilst others grown in poor soil only three or four. They reach their prime at about twenty years, but many have been known to bear fruit for sixty and seventy, though after the first score years the fruit is poor and scanty.

I was anxious to see the trees in blossom, but learnt that I should have to wait for that until the "latter rains," that is to say, the months of September, October and November. The natives believe that the heavier the "latter rains," the greater the quantity of oil the berries will contain. The berries take about four months to mature, so I saw them at their best, and magnificent specimens they were.

I was fortunate enough to secure the photograph of a native performing the first operation of plucking the berries from the tree. The snapshot shows with what ease he performed his apparently impossible climb. The operation is soon explained. With two ropes made of straw he makes two loops, which are passed round the tree. A wicker ring is attached to either end. Through the right he passes his leg up to the thigh, on the left he rests his foot; with this purchase he

raises the right loop some distance above him, and thus resting, raises the left loop in a similar manner, and so on, until he reaches the top. Attached to his waist, the climber has a rude cutlass with which to lop off the bunches of fruit from the stalks. The rapidity of the man's movements was remarkable, though no doubt the rough bark of the tree was of great assistance to him, by preventing the rope from slipping.

Having cleared the ground beneath two or more trees, the next process is to dig a deep pit in some convenient spot. Then the trees are denuded of their fruit, the bunches being cut into small sections of which they are composed, and thrown into the pit. When the pit is full, it is covered with leaves.

Native opinion is divided as to the original use of these pits. It is asserted by some that they were merely intended as storage places for the fruit, where they could be kept safe from the ravages of wild beasts. Others hold that the fact that the pits are covered clearly indicates that this form of storage was adopted to induce fermentation in order to loosen the berries from the stalks, and thus save labour. The fact that this very saving of labour resulted in the production of "hard oil" of inferior quality appears to be considered of little importance.

One of my photographs shows such a pit, round which a score or more little niggers are congregated. In the foreground of this picture will be seen two large earthernware pots; these, as we shall see, play an important part in the process of oil manufacture. The nuts strewn on the ground contain the kernels, which are left there to dry before they are cracked, and the shell removed from the core.

Taken out from the pit each berry is separated from its sheath-like covering, and placed in pots built into a long earthenware oven, ventilated at intervals, and fired with hard wood, the shells of old kernels and the dry pulp of the berry. A slow and steady fire is essential in the boiling of the berries. The ovens are usually constructed to hold about a dozen pots. A certain quantity of water is added to the berries, and the whole must be assiduously stirred as it boils.

As soon as the enveloping pericarp is soft the berries are heaped up in stone troughs or earthenware pits, lined with stones specially prepared for the purpose, and beaten with sticks by half a dozen men until it is loosened from the nut. The berries are then handed over to the women, who wash them in hot water, and separate the pericarp from the nuts, which are cast on one side ultimately to be cracked and the kernel extracted. The final stage thus reached, the pericarp is again placed in the ovens with a small quantity of water and boiled. As the oil rises to the surface it is skimmed off and placed in the earthenware receptacles already referred to. As the boiling proceeds boys stand over the ovens stirring the contents of the pots.

Having extracted as much of the oil as is possible by boiling, the pulp is put into a kind of net of coarse twine, and this being placed on a grating formed of bamboos over a large earthenware pot, the bag is squeezed by means of cords and levers, the resulting oil being added to the rest.

In the cooling process it has become as hard as beeswax, and has to be cut with a knife. As a rule, the natives among themselves squeeze this oil into measures; but when selling to merchants it is reduced to a liquid state and carefully measured.

When the oil is brought down in puncheons and taken to a merchant's factory for sale, he tests the quality of the oil by inserting a "trier"—a long brass tube—into the bunghole of the barrel, and, covering the end, brings up some of the oil. This he transfers to a copper pan, and, heating it over a fire burning on a brazier, removes it and leaves it to cool. On examining the sediment subsequently, he can tell at once the quality of the oil.

It is now ready for sale. No agent of any firm being present on the spot to purchase, it is open to all comers. Kudjoe and his wife—or one of his wives—think they can do a stroke of business by buying and selling at a profit. A palaver ensues between seller and buyer; eventually,

everything being arranged to their mutual satisfaction, we see the happy couple, each laden with a load of oil and kernels, on their way to the nearest European purchasing area.

Carefully tested, we shall find each load to approximate more or less to 60 lbs. in weight. The photograph represents two such loads—the man bears the palm-oil and his dusky better-half the kernels. He may have paid anything between 4*d.* and 6*d.* per gallon, she anything from a farthing or less per pound; and in happy frame of mind they seek the producing areas of Man Kessim, Tarkwa, and Akra to sell the same at a substantial profit—say 8*d.* a gallon for the oil and ½*d.* a pound for the kernels (usually 2*s.* per 60-lb. load).

If we take 300 gallons of oil as representing a ton, and 7½ lbs. representing a gallon of oil, we find that it costs the merchant, more or less, purchasing on the spot, £7 9*s.* 6*d.* per ton, which, according to the last Liverpool market quotations, sells there for £22 15*s.* With regard to kernels, what he purchased on the spot for £4 per ton sells in Liverpool for £10 12*s.*

Native opinion would appear to differ considerably as to the quantity of oil to be obtained from each tree's crop per annum. Some assert that a good tree's yield should be 3 gals. of oil, whilst more cautious men put it at a gallon. Personally, I should be disposed to think that, if we split the difference and make it 1½ gal. per annum, we should not be far out.

Although the oil is frequently brought down for sale, as depicted in the photograph, it is more usually conveyed in native earthenware pots, supposed to contain 16 or 17 gals. As nine pots are computed by the natives to be equivalent to a puncheon of a capacity of 150 gals., and as each pot is sold for 8*s.*, it will be found to work out at the same rate as previously mentioned.

It has been estimated that for every ton of oil made there should be 2½ tons of clean kernels, but the exports show nothing like this proportion, in fact just one-half the quantity is annually exported.

This is not at all to be wondered at when we observe the careless and improvident manner in which the natives leave the nuts scattered all over the place.

In fact the whole native process is defective. The berries should be gathered from the tree when just ripe; and, instead of lazily throwing them into a hole and collecting the fruit by fits and starts, they should be immediately removed from their sheath-like covering, and boiled to soften the pericarp. Leaving them to ferment darkens the colour of the oil, and causes it to harden and to be contaminated with the dirt of the pit.

The separation of the pericarp from the nut by the primitive method of beating on stone troughs, causes much waste of oil in the first place, and in the second, does not remove all the fibre. The hand-squeezing of the fibre naturally fails to extract all the oil. The final boiling should be unnecessary, as this further darkens it.

Unfortunately adulteration is resorted to. In the first place, we have the accidental contamination during the process of manufacture, owing to the dirty habits of the people; secondly, the adulteration is intentional, a fine red-earth being mixed with the oil at Saltpond. The result of all these drawbacks is very patent.

From my observations it was clear that, at all events in Saltpond, not a fifth of the palm-tree's fruit was manufactured into oil. All this is owing to laziness, the demoralising practice of keeping "funeral customs," the frequency of litigation, and the few wants of the native.

If Europeans would go in for the manufacture themselves, a remarkable change would result. I fail to see why it should not be as easy to obtain a lease of, say, 500 acres of palm land from the natives as it is to secure a mining concession. Their co-operation should be invited; for, of course, a manufacturer would be dependent on the natives for labour. All that really would be required would be to superintend, control, and systematise the cultivation and manufacture—not on revolutionary lines, but gradually. Of course the European would have to live on the spot. The great complaint of merchants

1.—EARTHENWARE BEATING POTS.
2.—NATIVES CARRYING OIL AND KERNELS TO MARKET.

3.—EXTRACTING THE OIL BY HEAT AND PRESSURE.
4.—CONVEYING OIL DOWN RIVER TARKWA.

who deal in this product is the want of good roads. With few exceptions there are really no roads in the Colony—only mere bush-paths. The chiefs, however, are encouraged by the Government to keep their "roads" clean by quarterly grants of 10*s.* per mile. From the oil-producing area of Abassa to Akra, the shipping-port in the Saltpond District, a very fine road exists, owing to the energy of a chief. It is 15 mls. long and about 10 to 15 ft. wide. Over this road ox-wagons could easily be drawn, or puncheons rolled. Only the River Tarkwa would require to be bridged; and, as will be seen from the photograph, it is not very wide and could easily be done.

But the question is whether, under present conditions and the spasmodic and comparatively small quantity of oil produced, the Government would be justified in expending a considerable sum of money on the off chance of merchants purchasing on the spot and sending down their produce in heavy casks; for it must be borne in mind that at present the merchants prefer purchasing oil and kernels at their own factories at a higher rate, rather than have a native agent on the spot, who purchases, though at a lower price, an inferior oil, and kernels from which the shell has not been removed. Moreover, experience shows that these agents often appropriate the advances supposed to be made to the native for the purchase of these products.

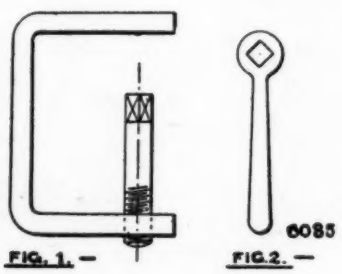
If native cattle were bred for use in carts, a great improvement in the roads would be sure to follow. But a killing lethargy seems to prevail; and, whilst men talk glibly of importing mules and cattle which they know cannot live, they ignore the beast which is to hand, and is by nature admirably adapted to the work.

Oil mills have also been talked of for extracting the oil from the kernel, instead of shipping them to England; but I fail to see how the native is to be induced to collect the nuts for crushing, when he is too lazy to do so for sale.

In conclusion, I firmly believe that, if capital were invested in this industry, and the whole process, from the growing and pruning of the palms to the export of the oil, were superintended by energetic Europeans, fortunes could be made, which would benefit the colony, as well as the enterprising capitalists.

A Tap Guide.

A useful accessory for tapping is shown in the illustration (Fig. 1), and its application materially assists in the tapping of holes where space is limited. A piece of ½-in. bar iron, bent to the form shown, is then drilled and tapped with the tap to be used. It may be fixed in the required position and wedged in place, its open form permitting the use of a single-ended tap-wrench, as Fig. 2. Better results in the form of more perfect threads are thus secured with very little more trouble. W. E. S.



A TAP GUIDE.

Air Compressors and their Valve Gear.

By CHARLES HURST.

On approaching the subject of air compressors from the valve-gear standpoint, it is convenient to divide them into two classes, those having automatic valves, and those in which the valves are positively controlled. Many compressors, it must be admitted, combine the two classes in their valve-gear, nevertheless the classification here adopted is a convenient one.

In comparing the merits of automatic and positive valve-compressors, it is necessary to consider the conditions under which they operate, before a true estimate of their relative advantages can be formed. Dealing first with the suction valves, those of the automatic class have the advantage that no extraneous gear such as eccentric rods and levers are necessary; but on the other hand the fluid resistance of an automatic compressor exceeds that of the positive type. Referring to Fig. 1, which shows diagrammatically a suction valve of the automatic class, it is evident that, before this valve can open, the pressure in the cylinder must be less than the pressure of the outside atmosphere. In the first place the spring offers some resistance to the opening of the valve; and further, the atmosphere acting on a smaller area than that part of the valve exposed to the cylinder, must be in excess of the pressure in the cylinder before the valve can open. The effect of these conditions is to rarify the air drawn into the cylinder and thereby not only increase the resistance to the compressor but also to diminish its capacity. In most indicator diagrams from air compressors the result of a throttled suction is not clearly defined because the strength of the indicator spring is too great to show the rarefaction of the suction charge; but, if light spring cards were taken, the effect would be clearly seen in all automatic suction-valve compressors. Some years ago the writer indicated an air compressor at Wigan, and as the suction valves were suspected of throttling the inlet charge, a light spring card was taken, of which Fig. 2 is a reproduction. Here the throttling effect is clearly visible, and amounts to an average of $1\frac{1}{4}$ lbs. per sq. in. throughout the suction stroke, thereby reducing the capacity of the compressor about $8\frac{1}{2}$ per cent. This is a serious loss of capacity, and is instructive in showing the effect of a slight imperfection in the valve gear. Positive action suction valves evade much of this loss, but their introduction leads to other considerations, which, if neglected, will more than nullify any gain arising from reduced suction-resistance.

Take the case of an air compressor delivering into a receiver at a constant pressure, and giving an indicator diagram similar to Fig. 3. At the end of the

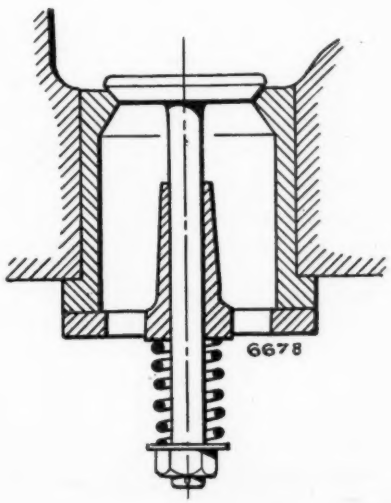


FIG. 1.

FIG. 2.

delivery stroke, and when the piston begins to recede, the air at receiver-pressure left in the clearance space expands upon the retreating piston, as shown by the approximately hyperbolic curve at *A B* meeting the atmospheric line at the point *B*. Now the point *B* is where the suction-valve should open, and any departure from this point of opening entails loss. In a well-designed automatic valve-compressor the valve opens at the right instant irrespective of any attention on the part of the attendant engineer, but an automatic valve-compressor requires an exact setting. The effect of improper opening is clearly illustrated in the diagrams Fig. 4. That to the right-hand is taken from a compressor in which the suction-valve opens prematurely. The result of this faulty action is to allow the residual air in the clearance spaces to escape down the suction inlet, and the force which it might have exerted on the piston whilst expanding down to atmospheric pressure has been thrown away. The correct indicator diagram is shown by dotted lines, and the loss of power is represented by the area shaded. The left-hand figure shows the effect of late suction-opening. Here the residual air has expanded below atmospheric pressure, and an increased resistance has been thrown upon the piston to the extent of the shaded area. Now it is a comparatively easy matter to set the valves of a compressor when the machine is delivering air into a receiver with a constant pressure; but when that receiver pressure fluctuates considerably, a positive suction-valve compressor must be working under uneconomical conditions, because for every pressure there is a particular instant at which the suction-valve must be opened to avoid loss, and it is obvious that, if correctly set for one certain pressure, the valves will be incorrectly adjusted for all others.

To illustrate this point clearly, take the concrete case of a compressor with a clearance volume of say 100 cub. ins., and delivering air at 75 lbs. per sq in., by

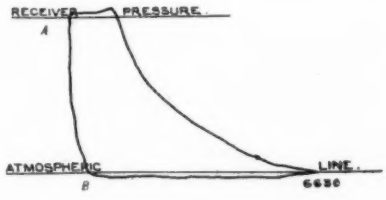


FIG. 3.

gauge. If the suction valve is correctly set, it will open when the air has expanded back to atmospheric pressure, this will occur when the piston has displaced about 500 cub. ins. on the return stroke. Now suppose the receiver pressure reduced to 45 by gauge. Under these conditions the valve should open when the piston has displaced 300 cub. ins., and with the previous setting the compressor

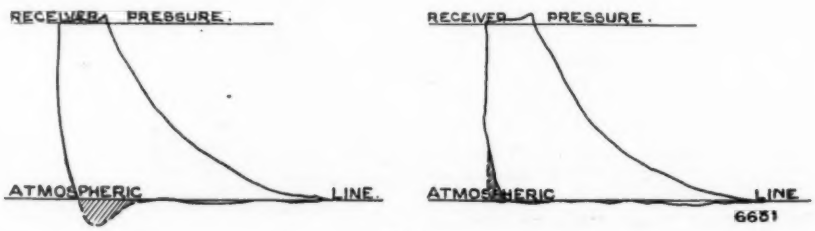


FIG. 4.

would be working at a disadvantage. From these considerations, it would appear that, when the receiver pressure is constantly changing, a positive suction-valve compressor is at a disadvantage; but where the pressure is fairly constant or where the changes are of sufficient duration to justify a re-setting of the valves this type is to be preferred.

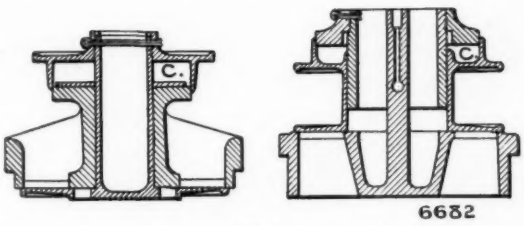


FIG. 5.

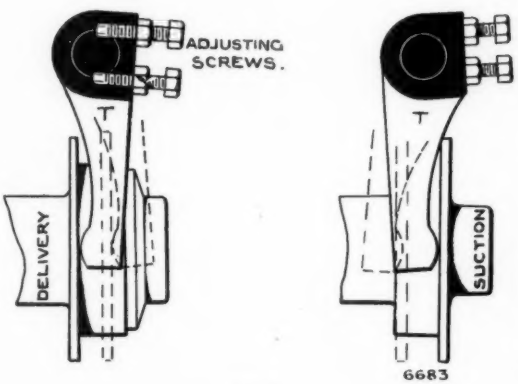


FIG. 6.

In compound compressors the low-pressure or intake-cylinder may with advantage be fitted with mechanically moved valves for both suction and delivery, because in this cylinder a constant delivery-pressure to the intercooler is obtained in spite of fluctuations in pressure in the delivery main; and when the valves have once been set they require no further adjustment in the timing of their functions. It has been previously stated that the fluid resistance on the suction-stroke has a considerable effect in reducing the capacity of a machine, but in the second cylinder it has little or no effect on the output.

If in entering the cylinder the air passes in thin streams through hot passages or ports, or past hot valves or seats, it will become rarefied, and thereby reduce the capacity of the compressor. The valve arrangements should therefore be designed to avoid this effect as much as possible. The passages leading to the suction port, should be kept away from the heat of the cylinder, and should be as large and as direct as convenient.

Automatic delivery valves of air compressors, are by far the most common type, and when well designed, are quite satisfactory, and it is not uncommon to find machines having positive suction and automatic delivery valves. The great difficulty with delivery valves of the automatic type is to avoid the severe banging or slamming to which they are liable. No such severe action occurs with suction valves, because they open and close when the pressure in the

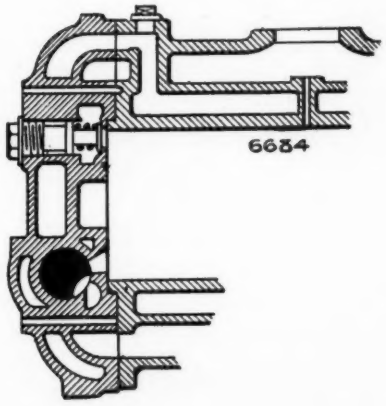


FIG. 7.

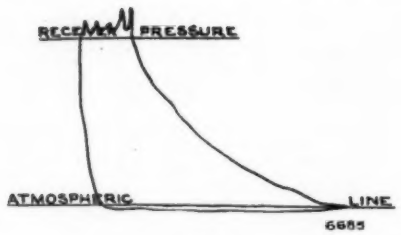


FIG. 8.

cylinder is at or near atmospheric pressure. The closing movement of a delivery valve is the severest; and any delay in closing, through sticking of the valve hinges or stems, throws a severe blow on the faces, and destroys them. With the object of avoiding this, the Reidler valve has been introduced. Figs. 5 to 7 will render the action of the valves clear. It will be noted that both suction and delivery are of the ring type, and present a double opening for air passage. Each valve is provided with a dashpot chamber *C*, which prevents vibration on opening. The valves are automatic in their opening, but the closing is assisted by tappets *T*, shown in Fig. 6. These tappets move the valves until the latter are about $\frac{1}{16}$ of an inch from the face, when they are free to fall on their face automatically. Having only $\frac{1}{16}$ of free movement in closing, no serious banging can occur, and at the same time a large lift can be given without the slightest fear of hammering the faces unduly. Both suction and delivery valves are closed exactly at the end of the stroke, and therefore the tappets can be mounted on one spindle and driven from one rod, which is usually actuated by an eccentric on the crankshaft in the case of power-driven compressors, and from a cam on the wrist-plate where the compressors are driven by Corliss engines.

A section of the cylinder end of a compressor having positive driven suction and automatic delivery valves is shown in Fig. 7. The inlet valve is of the Corliss type, and is actuated by a wrist-plate and levers in a manner similar to the exhaust gear of a Corliss steam engine. The eccentric is set in such a position that, when the piston has displaced a volume sufficient to allow the residual air in the clearance spaces to expand down to atmospheric pressure, the valve is just edge and edge with the port in the cylinder, whilst the closing of the valve is timed to occur exactly at the end of the suction stroke. The dwelling angle of the valve should be reduced to a minimum by the proper disposition of the wrist-plate, pins, and valve levers, as is arranged in the exhaust valve gear of most high-class Corliss steam engines. As to the delivery valves, it will be noted that they consist of a series of the mushroom spring-loaded type. Opposite each valve is a plug to give ready access to the valve and seat, which can both be withdrawn without disturbing the cover.

Small delivery-valves of the spring-loaded automatic type, although convenient for access and free from the excessive banging of a large valve, have a disadvantage which is shown graphically in the indicator diagram Fig. 8. A perfect valve opens the instant the pressure in the cylinder reaches the receiver pressure, but the poppet-valve is prevented from opening at the right instant because of its

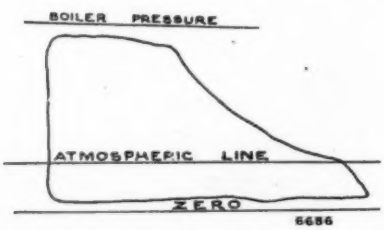


FIG. 9.

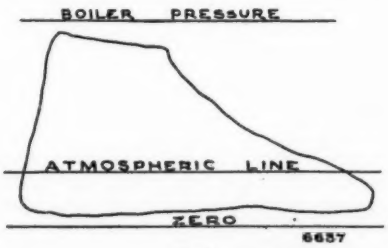


FIG. 10.

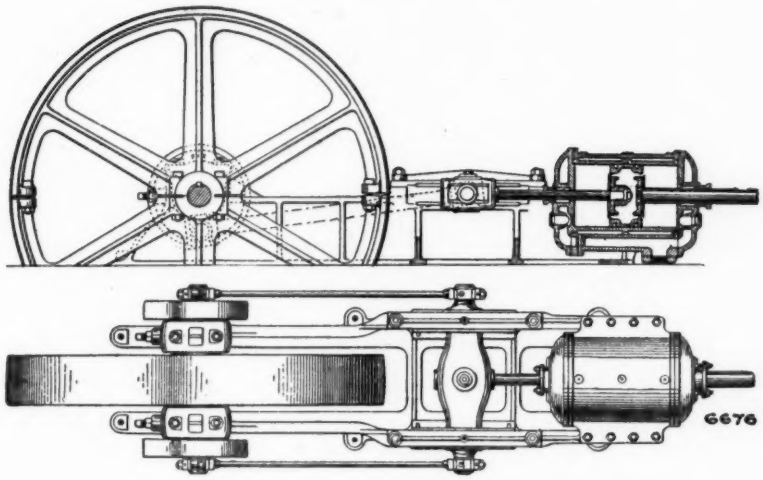


FIG. 11.

own weight, because of the spring resistance, and by reason of the unequal areas respectively opposed to the cylinder and receiver pressure. The first two reasons are not of much account; but in order to appreciate the effect of unequal areas, take the case of a delivery-valve having a seat 3 and $3\frac{1}{2}$ ins. diameter on the inside and outside of the seating respectively, and assume a receiver-pressure of 100 lbs. per sq. in. The total pressure on the receiver side of the valve is 962 lbs., and before the valve can open the pressure in the cylinder must be—

$$\frac{962}{\frac{\pi}{4} \times 3^2} = 122 \text{ lbs. per sq. in.}$$

As soon as the valve opens there is an excess of the pressure on the delivery side, and the result is a violent vibration or dancing of the valve, which in addition to injuring the valve-springs throws severe stresses on the crank-pin, piston-rod, and bed-plate of the compressor.

The above considerations show the importance of making the valve-seating as narrow as is consistent with durability, to avoid the result shown on the delivery line of the diagram.

Few classes of machinery are subjected to more severe stresses than steam-driven air compressors; and as these may, for the most part, be eliminated by a judicious valve-setting it will be convenient to consider the matter in the present article. The great shock with most compressors occurs on the dead centre when, under ordinary conditions, the load on the piston-line is equal to the sum of the steam and air-piston loads; for when the crank is in this position the full steam pressure is on the steam piston due to lead of the steam valves, and also on the air-piston, and as both these forces are acting in one direction the resultant force is the sum of the two components. To resist this great force, most modern compressors are made extra strong in all parts between the crank shaft and the steam cylinder. The piston-rod is larger in diameter at the crank end of the steam cylinder than between the steam and air cylinders, a state of things which appears to be absurd until the nature of the stresses is thoroughly appreciated. To avoid this shock it is only necessary to dispense with lead and set the steam-valves so that the port is not opened until the crank has passed the dead centre.

If it were possible to make the steam-valve gear-setting unalterable, most makers would send out their machines with negative lead, and the necessity for extra strength in the piston line and the framing would disappear, but as all valve-gears are more or less at the mercy of the attendant engineer, whose ideas of valve setting may be anything but scientific, the makers are compelled to design their machine to withstand the worst possible case of valve setting. The accompanying diagrams from the steam cylinder of an automatic valve compressor will be interesting as showing the actual effect of improper setting when operating with the steam distribution portrayed by Fig. 9. This compressor gave much trouble. The pedestals were fractured after some three months' work, and when these had been replaced the piston-rod gave out through the cotter hole in the crosshead, and the crank pier was slightly bent. The steam distribution was afterwards altered as shown in Fig. 10, and under these conditions the compressor has given no trouble.

The Ingersoll-Serjeant piston-inlet compressor is an interesting example in which a very free suction inlet is attained with an automatic valve, the inertia of which is useful in effecting prompt opening and closing. Referring to Fig. 11, which gives a section through the cylinder of one of these compressors, it will be noticed that the inlet valves consist of steel rings in the piston. They are restricted in the lift by a series of pins fitting into slots in the valves. The air enters by a tube at the back end of the cylinder and passes to the centre of the piston, and thence to the cylinder, through either of the valves. As the piston commences its stroke it has a tendency to leave the valve behind it, because of the latter's inertia, and would do so were the pins not provided. At the end of the stroke the reverse action takes place, when the valve has a tendency to outrun the piston, thus rendering closing extremely prompt. In consequence of the above-described action, the suction is extremely free, and the makers claim that a freer inlet is obtained than with any other type of compressor having automatic valves. The inaccessibility of the valves in the piston would be a serious objection if frequent examination and adjustment were necessary; but, in this case, there are no springs whatever, and the valve itself is a simple ring of high quality mild steel, and practically indistructible. As to the delivery valves, it will be seen that they are of the usual poppet spring-closing type, with screwed cap covers to render examination easy.

Besides the types already mentioned, the hinge valve is sometimes employed. This valve, however, is liable to severe banging unless the lift is small, and there is special gear provided to prevent dancing on the face. For low pressures, slide valves are sometimes used, but it is obvious that this type is not well adapted for giving small clearances. Blowing engines, which are a type of low-pressure air compressors, have sometimes been fitted with rubber valves, and sometimes with valves of leather; but such designs are necessarily limited to low pressures, both on account of their being unable to resist high temperatures as well as high pressures.

The Construction of Towns.

By Prof. L. CLOQUET (University of Ghent).

MANY towns are at the present time undergoing important constructional transformations, the process of which calls for the solution of many problems, and raises many difficulties. It is to be regretted that, in many instances, the reconstruction or extension is being carried on without due consideration being paid to the special principles which should regulate town construction, and it was only recently that we drew attention to the action of various local authorities of greater London in permitting the haphazard construction of streets without due regard being paid to through-traffic requirements certain to arise in the future.*

At a conference recently held at Ghent, under the auspices of the *Association des Ingénieurs de Gand*, Prof. Cloquet, in an interesting communication presented thereat, reviewed the conditions governing the construction of towns. As his remarks merit the careful attention of municipal engineers and others interested, the substance of the Professor's address has been reproduced here, the first section dealing with the Planning of a Town, the second, with Street Design, and the third with Public Places.

The whole question is one which has been made the special study of two eminent continental specialists, to whom Prof. Cloquet states he is largely indebted for the theory which he expounds. The first is M. Stubben of Aix-le-Chappelle, and the other is the late M. Camille Sitte of Vienna, whose work on the construction of towns, published in 1889, produced some sensation. It is to be feared that this work is not so well-known or appreciated in this country as it should be. [ED.]

THE laying out of the plan of a town comprises the delimitation of the streets and squares, the fixing of the sites of public buildings, and the apportioning of building areas. In carrying this out, regard must be paid to the exigencies of traffic, to the purposes for which the various buildings are required, and to the rules of hygiene. Consideration should also be paid to the laws of æsthetics.

The facilitation of traffic is the prime function of the street, the laying out of which should therefore be made to suit the principal traffic-currents both present and future. The streets as a whole, form a network varying in form and complexity acccording to the traffic, local circumstances and adventitious peculiarities. Of these networks, two particular types may be distinguished, viz., one which resembles in design a spider's-web, and the other a draught-board.

The main lines of traffic, or *arteries*, join up the various centres of traffic or the points of convergence of movement in a town, such as a railway station, pier, market, bridge, etc.

In very old towns, such as, for example, some of those in north Belgium which in times past enjoyed great freedom and an intense form of communal life, the market, situated between the town-hall and the cathedral, and into which ran all the main thoroughfares, generally formed the centre of agglomeration.

At Bavai and Tongres an octagonal column marks the centre of convergence of the Roman roads in those towns, while at Tournai the triangular market-place is formed at the junction of the two Roman roads from Bavai and Tongres. But in modern towns the market-place has no longer the same importance, and the absolute centre of traffic has given place to a group of centres connected by broad thoroughfares, having an easy gradient.

The main arteries traverse the street network, and connect two centres of circulation, the more important of such thoroughfares being called arteries of penetration. Examples of these may be found in the new Kingsway, between the Strand and Holborn, in London (Fig. 1), and the projected thoroughfare across the town of Bordeaux (Fig. 2).

The main arteries of towns of the spider-web type are either radiating or annular (Figs. 3 and 4). Radiating thoroughfares constitute in a way the skeleton of the town. Rome and other ancient cities have a well-defined system of radiating thoroughfares. The town area is divided

Cf. Vol. x. p. 295

by such streets into sections, which are again subdivided by radiating lines of secondary importance. A second order of streets is constituted by those connecting the sections amongst themselves; they are the annular thoroughfares (Ringstrassen), which may be again subdivided in order of their importance. Another class, the cross streets, consists of those which, considered as a whole, are annular in form, the individual sections, however, consisting of rectilinear lengths joining two radiating streets.

FIG. 1.—PLAN OF LONDON'S NEW THOROUGHFARE, THE "KINGSWAY."

At the periphery of a city ordinarily runs a broad annular artery, planted on both sides with trees, and generally called a *boulevard*, a term which is also applied to interior streets in which the path for pedestrian and the roadway for vehicles are separated by a range of trees. The area enclosed by radiating and annular streets, consists of blocks which in theory are trapezoidal in form, but in practice approximate more to a rectangular shape. They are sub-divided into convenient allotments by parallel streets.

Referring to Fig. 3, the point *B* can only be reached from *a* by following a zig-zag path. Such a route would not meet the exigencies of traffic where the two points in question are centres of circulation. To meet the case a direct road following the hypotheneuse of the triangle and cutting the mesh diagonally, would be called for.

At the junction of the diagonal thoroughfares is formed an open space, such as a square, place or circus, the function of which is to facilitate the passage from one street to another.

It frequently happens that it becomes necessary to pierce the diagonal routes by a main thoroughfare, owing to lack of foresight when developing the town, or other circumstances. Such examples are to be found in the Kingsway and Shaftesbury Avenue in London, and the project to connect in the town of Brussels, the Place Royale, the Place Sablon, and the Gare du Midi in direct communication.

The system of radiating, annular and diagonal streets should be primarily regulated from the point of view of facilitating both pedestrian and vehicular traffic, but it must also conform as much as possible to the pre-existing system of streets within the limits prescribed by the natural topography of the place and property considerations.

In connection with local physical conditions, it is above all important to take into consideration (*a*) hilly areas, where the streets must depart from a rectilinear path

in order to obtain an easy gradient, (*b*) the traversal of a town by a river which deforms the street network by necessitating secondary points, and the convergence of the streets thereto.

Towns traversed by a river—such as London, Paris, Vienna, Rome, Florence — provide an example of an arterial system converging towards the bridges, between which converging elements run streets parallel to the river, cut in two by others running perpendicular to the stream. This forms a combination of the spider-web and quadrangular types (Fig. 5). The plan of old Paris shows this formation most clearly. A fine example of the cob-web type is found in the case of Bologna (Fig. 6). In this example, however, there are two centres of radiation, situated on the opposite sides of a central quadrangle forming the nucleus of the city.

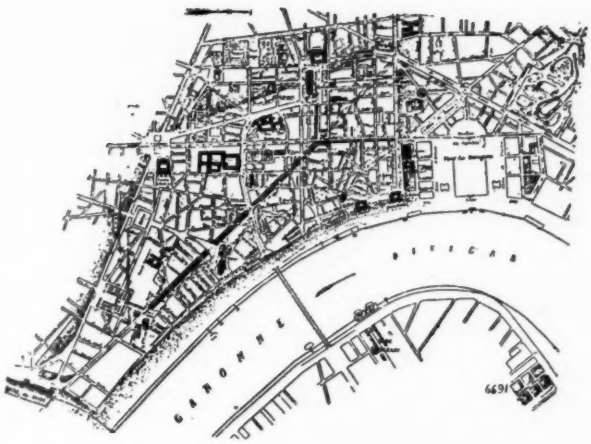
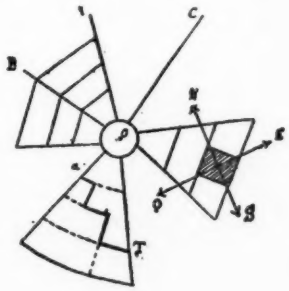


FIG. 2.—PLAN OF BORDEAUX SHOWING PROJECTED NEW THOROUGHFARE.

Bruges affords another example of the same system; modified, however, by the inflection of the streets necessitated by topographical causes, the chief of which is the numerous canals which wind through the town (Fig. 7). Another good example is to be found in the town of Carlsruhe (Fig. 8), which, however, has the disadvantage of having the *château royal* as a centre of the street network —a building which is not a true centre of traffic circulation. The system has also been adopted, on a semicircular plan, for the city of Braïla in Roumania, situated on one of the banks of the River Danube. The most notable instance is to be found in the case of that quarter of Paris in which is situated the Arc de Triomphe, that edifice forming the centre of a dozen avenues.

The plan involving circular and radiating thoroughfares is so logical that it has been applied, not only to streets, but also to canals, in the city of Amsterdam, where they form five semicircular arteries, cut by radiating canals, the streets being



FIGS. 3 AND 4.—EXAMPLES OF "RADIATING" AND "ANNULAR" CONSTRUCTION.

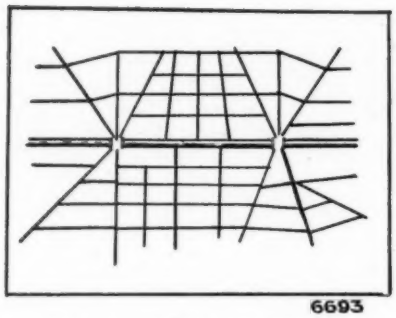


FIG. 5.—SKELETON OF A TOWN TRAVERSED BY A RIVER.

formed exactly on the model of the canals (Fig. 9).

Radiating thoroughfares have, as a feature of primary importance, the means of continuous connection of the centre of the town with the suburban districts; they consequently lose much of their importance in the case of an isolated town, such as La Haye, in which it has been sought to provide a means of communication only with the quarters comprised by the *enceinte* of the town itself (Fig. 10).

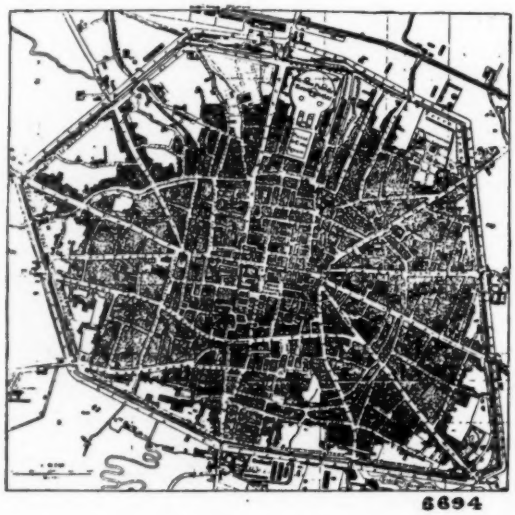


FIG. 6.—PLAN OF BOLOGNA.

In Rotterdam the streets have been planned on a system of parallels, following the line of canals which traverse and surround the city forming a network of quays (Fig. 11).

We will now proceed to deal with the second or chess-board type.

This system is perfectly realised in the plan of Turin (Fig. 12) and in that of Mannheim. It is the prevailing style adopted in the larger towns of America.

Washington is the only American town, however, which has been constructed throughout on a completely methodical system; Philadelphia has been partly so planned, as has also that portion of New York constructed posterior to the year 1807.

The plan of these towns consists of a rectangular meshwork, and in order to travel from one point to another in a diagonal direction, it is necessary to turn at right angles at each square. In this very crude form of construction, consideration has evidently been given only to building facilities, and not to the convenience of the traffic.

The plan of Washington was due to Lenfant (Fig. 13). Basing his design fundamentally on the chess-board plan, he however chose, as well as the local physical conditions would allow, points favourable to the erection of grand monuments, joining these artificial centres of circulation by broad thoroughfares cutting across the individual squares. One of these arteries connects the Capitol and the White House. The Congress Chamber is the centre of convergence of 16 arteries; the President's house forms another such centre of radiating thoroughfares; while a third is the site of the Washington statue. It should be noted that these centres, more particularly the last, are, so far as traffic is concerned, of theoretical importance only.

As for New York, this city is an agglomeration of 2,000

blocks, each measuring 200 ft., and not one of these squares is sufficiently large to permit the erection of a monument which would appear with advantage. When in 1807 a commission elaborated the plan of the town, the only irregular thoroughfare, viz. Broadway, the great commercial centre, had attained too much importance to be submitted to rectification. Afterwards, however, it was taken in hand and straightened for some 2½ miles of its length, thus destroying its picturesque aspect.

Philadelphia is cut up in square blocks by a series of streets crossing each other at right angles. They are all of the same character, their length and perspective rendering them extremely monotonous. More than thirty towns and villages have been absorbed in the growth of Philadelphia, and in this large area has been developed the implacable chess-board network, the original conception of Wm. Penn, with its rectangular blocks, straight streets, absolutely no curves or diagonals, and unfortunately without the parks that the designer had projected (Fig. 14.)

An exceptional combination of circumstances is necessary in order that a town may be constructed to a preconceived plan. Such conditions have obtained in connection with the newer towns of America, as also under the absolute monarchs of antiquity and under the potentates who built, on the chess-board system, the city of Babylon, stated by Herodotus to have occupied a regular square 8,000 yds. in length, and divided by 50 streets, cutting each other at right angles. Other examples are to be found in (*a*) some Egyptian towns, notably Alexandria,

FIG. 7.—PLAN OF BRUGES.

which was also laid out on the rectangular system; (*b*) in the *bastides* or new towns of the middle ages erected by kings and nobles, with the idea of attracting a population to their lands.

Circumstances permitting the erection of an entirely new city are very rare in these days. Not long ago, however, an opportunity occurred in the case of Dalny, erected by the Russians at the terminus of the trans Siberian railway.

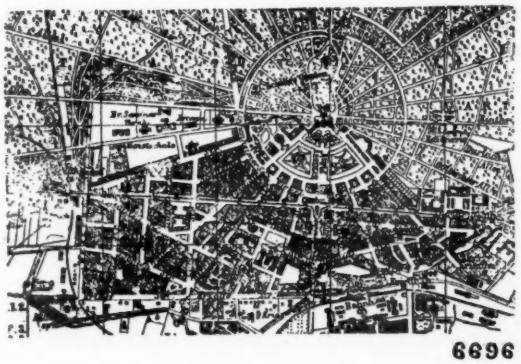


FIG. 8.—PLAN OF CARLSRUHE.

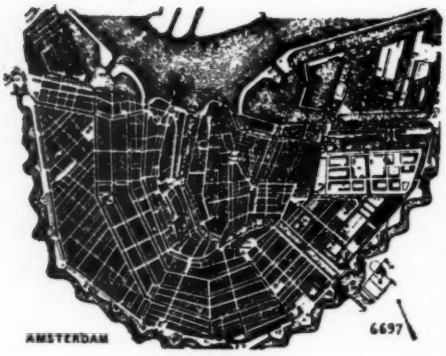


FIG. 9.—PLAN OF AMSTERDAM.

The plan of this town was drawn up entirely by the Russian engineers in their office, and includes centres of traffic, such as public places, railway station, etc., placed in communication with each other by arteries, from which radiate streets to the central commercial quarter. The radiating thoroughfares are connected with each other by annular streets, and several eccentric portions are built on the rectangular system.

To appreciate the difference of attraction which can exist between two towns, one of which has grown up freely, and at the suggestion of local circumstances, while the other has been the outcome of one dominating and fixed idea, carried out without regard to the comfort or pleasure of the inhabitants, it is only necessary to compare the plans of Goa (Fig. 15) and of Batavia (Fig. 16). The picturesqueness of a town is the secret of its charm, as exemplified in the cases of Venice, Nuremberg, Bruges, which have escaped rectification.

The picturesque must not, however, be realised at the expense of hygienic or traffic considerations. All interests, however, are sometimes happily combined, especially in towns where main thoroughfares have been constructed without upsetting local and natural conditions. London may be included in this category.

After the great fire, Sir Christopher Wren prepared a plan of reconstruction,

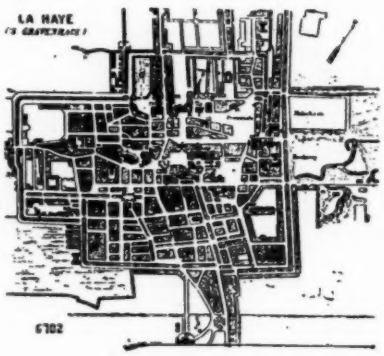


FIG. 10.—PLAN OF LA HAYE.

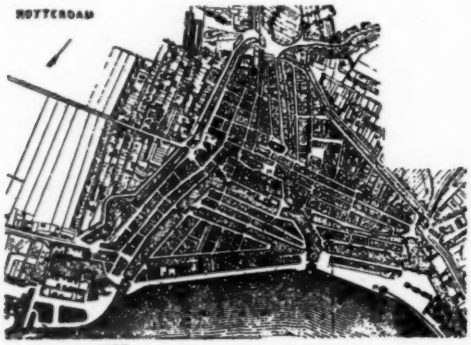


FIG. 11.—PLAN OF ROTTERDAM.

in which provision was made for the erection of churches and public monuments on isolated or commanding spaces. His plan, however, was not appreciated to the full, and consequently not adhered to. Hence important constructions occupy the site of ancient houses; and old winding streets, in some cases partly straightened, connect with important main thoroughfares.

The town, however, has been greatly modernised. During the last century twenty commissions elaborated schemes of improvement, and over fifteen millions were spent, much of which could have

been saved had the plan of Wren, who realised the modern principle, been adopted.

To the street-plan of London may be opposed that of Berlin, in which the rectangular system has been rigidly adopted, and the main thoroughfares run in monotonous straight lines.

Particularly curious is the lay-out of Carlsruhe, referred to above and illustrated in Fig. 8. It resembles in form a vast fan, in which the ribs are represented by the radiating thoroughfares. The principle, however, has in this case been greatly exaggerated and falsely applied. The streets converge implacably towards the *Château Royal* in such a manner that, in no matter what place, the pedestrian cannot escape the view of the ever-present monument. That which falsifies the whole system and makes a monstrosity of the application of a rational principle is, that this sole converging point is anything but a true centre of traffic circulation.

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FIG. 12.—PLAN OF TURIN.

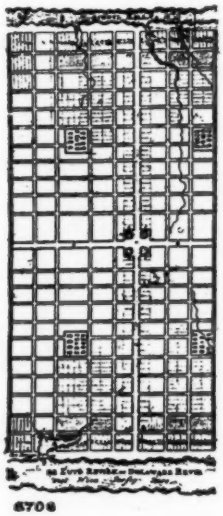

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FIG. 14.—PLAN OF PHILADELPHIA.

The check-board system is well-known in Europe, and is well exemplified in the towns of Turin and Mannheim.

In the case of the latter a single glance suffices to show the modern method of development now taking place in European towns, well illustrated also in the Esquilin and Quirinal quarters of Rome, the neighbourhood of the Rue Cavour in Florence and the Louise quarter in Brussels. All these neighbourhoods have been created without any other regard than that of convenience of sale of the areas on which they are constructed, and

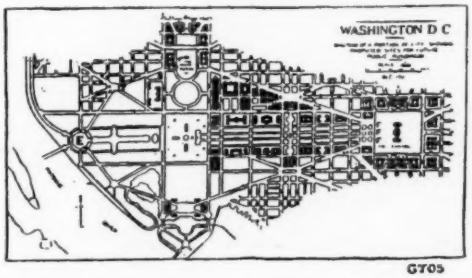

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FIG. 13.—PLAN OF WASHINGTON.

FIG. 15.—PLAN OF GOA.

consequently have the most commonplace and comfortless appearance.

At Florence, after having built the above-mentioned quarter, the authorities recognised the mistake that had been made, and the extension on the left bank of the Arno has therefore been carried out on the ancient plan; consideration, of course, being paid to the laws of hygiène and the needs of our epoch.

The conservation of particular localities from the points of view of scenery, architecture and historical associations must be made an essential condition in the erection of new districts as in the transformation of existing quarters.

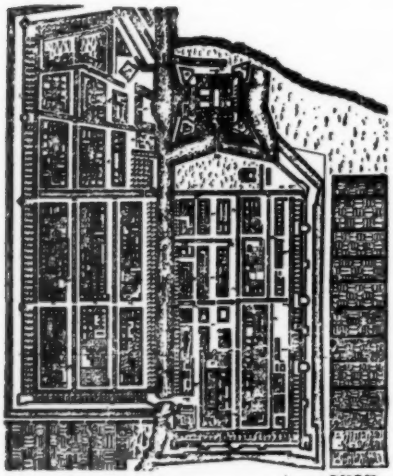


FIG. 16.—PLAN OF BATAVIA.

Among natural circumstances the most happy, perhaps, is the traversal of a town by a river or stream. In the case of Ghent, contemporary builders have recognised this, and dealt wisely with the banks of the *Coupure* (a canal), while their predecessors decorated the quays in an admirable manner, some of them being worthy to rank among the most beautiful sites of Europe.

The Seine and its banks have served to secure a reputation for Paris, and all capitals envy the happy ordering of things which has preserved to her such an admirable feature. It is scarcely the same in London, where the Thames only serves the purpose of a commercial highway.

In consequence, the river has been neglected, and even disfigured by the erection of warehouses and factories close up to the water's edge.

In New York the beauties of the Hudson River have been strangely neglected, at least for a considerable portion of its length; there being no quays or promenades from the Battery up to 72nd Street. Further on the banks have been converted into magnificent thoroughfares.

There is another element of the picturesque which is at the same time a factor of health—namely, vegetation. If this does not purify the air to the extent sometimes claimed, it provides freshness and shade. The plantation of trees, however, is only called for in the case of broad and commanding thoroughfares, or streets which are very ugly.

The idea of thus decorating the streets has something very seductive about it; but, except in the case of main arteries, it is destructive of all monumental aspect. The Dutch have so well recognised this fact that they have, in many instances, contented themselves with a single range of trees, planted in the axis of the street, in order not to mask the façades. It is in the villa quarters that trees are planted with the most happy effect.

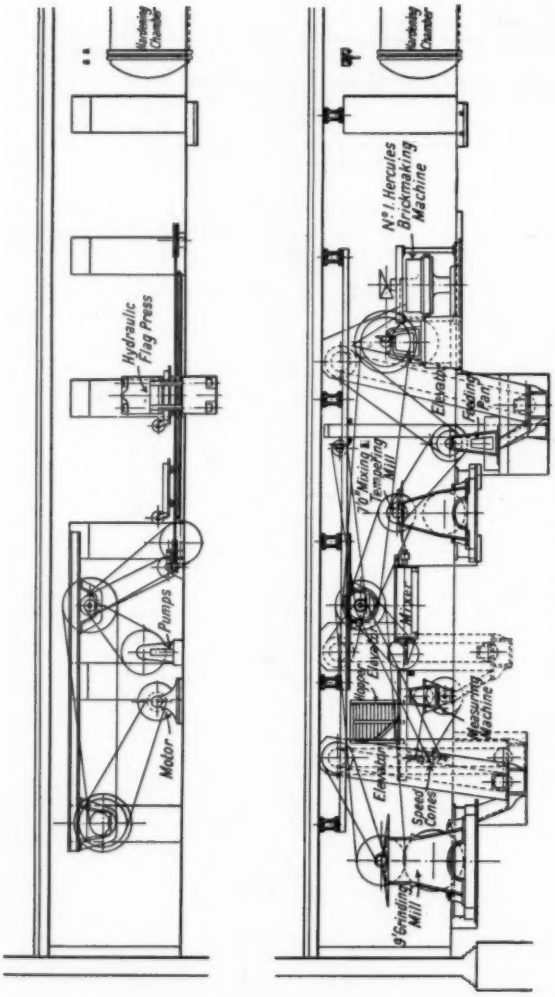
(To be Concluded.)

ENGINEERING PROGRESS.

Brick-Making from Destructor Clinker.

GREAT interest is being manifested at the present time by the Corporations of Great Britain in the utilisation of town refuse, and it is becoming rapidly recognised that the material which has hitherto been a source of much trouble to many local authorities can be by judicious manipulation turned to profit in many ways. The manufacture of bricks and flags from clinker obtained as one of the results of combustion in refuse destructors is a process which bids fair to show very satisfactory possibilities, as is evidenced by the results now being obtained at the Woolwich Corporation Destructor Works with a complete clinker brick-making plant. This plant has been supplied by the Queen's Engineering Works, Ltd., of Leeds, and, as will be seen from the accompanying illustrations, is extremely well arranged, slag entering at one end of the building and the finished bricks leaving at the other.

The burnt clinker from the destructor is brought by barrow, and is ground through ½ in. mesh in a 9 ft. perforated edge-runner grinding mill. This mill delivers the material to the boot of an elevator which carries it to an automatic measuring or proportioning machine. Alongside the clinker elevator there is a second elevator, which carries either the lime or cement, whichever is at the moment being used, to the measuring machine. The latter is in the form of an enclosed revolving cylinder having two sets of adjustable pockets round a circumference, one set for the matrix and the other for the amalgam, an arrangement which admits any required proportion of the two materials being measured automatically and continuously. The usual proportion of amalgam is from 6 to 8 per cent. A small paddle-mixer under the measuring machine collects the two materials; and, after giving them a preliminary dry-mixing, passes them to another elevator, which carries the mixture to a differential paddle-mixer, where the material is damped with water and thoroughly mixed together. This machine is continuous, and delivers to a special form of grinding and tempering-pan, where the material is thoroughly kneaded and worked to the required consistency. The tempering-mill is self-delivering, and the arrangement whereby this is effected is worthy of note. The pan-rim is stationary, and is bolted to the standards. In front of the rim is a hinged door, actuated by a hand-wheel and screws. When a charge of material is turned into the pan from a shoot situated above, it is allowed to remain until sufficiently tempered, when the door of the rim is opened inwards. The pan bottom continuing to revolve causes this door to act as a scraper, and the contents are thrown out in a few seconds, practically in one revolution of the pan bottom. A circular feeding-pan then takes these intermittent charges and strickles them in a regular flow to the elevators, one of which feeds the brick machine and the other the flag press. The same preparing machinery is thus used for both brick and flag plants, though it is not usual to work both at once as lime is generally used for the bricks and cement for the flag. In the brick-making process the material is next passed to a Hercules brick-press, where it is first strickled by the feeding pan into the moulds of a revolving table having ten moulds. The table then moves round one-tenth of a revolution, and the filled mould is brought under a rigid press-head, the plunger which travels in the mould being raised by a lever from below, thus pressing the brick between the plunger and the press-head. The next movement brings the mould over an ejecting plunger, which lifts the mould plunger to the level of the table top. The mould plunger then travels on a horizontal race fixed immediately below the revolving table, thus giving time for the brick to be lifted off by the attendant. When the mould reaches the filling position again, the plunger falls to a lower adjustable race which can be raised or lowered to give any desired feed. A pressure of 200 tons can be exerted, which is adjustable by the raising or lowering of the two columns carrying the fulcrum of the main pressure lever. It will thus be seen that three operations are performed between each movement of the table: one mould is filled, one brick is pressed, and another brick is ejected. The bricks are stacked on steel platform-wagons which are run into steam



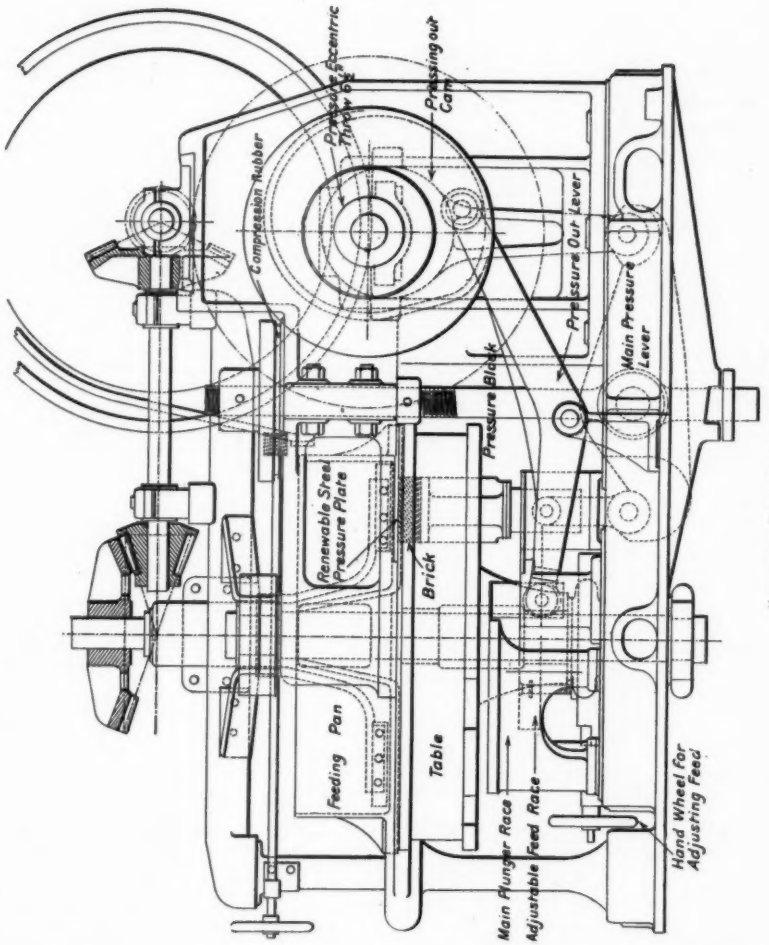
ARRANGEMENT OF CLINKER BRICK AND FLAG PLANT.

autoclaves or hardening-chambers, of which there are two, each 30 ft. long by 6 ft. 6 in. in diameter. Steam for heating these chambers is generated in the refuse destructor. The cost of making bricks by this process we are given to understand, works out at about 12*s.* per thousand.

For flag-making the same process is adopted, an hydraulic flag-press being used instead of a brick-maker. This flag-press is provided with two mould-carriages running alternately under the press-head, one being emptied and refilled while the other is under pressure. An important feature of this press is that only one ram and one set of stops are used. The moulds are so designed that, by turning a hand-wheel, the front of the mould moves away and unlocks the sides which swivel away, leaving the flag free to be lifted off. The importance of this arrangement is that the flag is pressed on a removable steel-plate provided with handles. The trouble of pressing out the flag by hydraulic ram and turning over the newly made, and consequently delicate, flag on to a wagon is thus avoided. The flag is carried away on its own plate, and is allowed to stand until the next day, when it is hard enough to be stacked on edge for weathering. The moulds are interchangeable, and four sizes of flags are provided for. The hydraulic power is provided by a set of duplex pumps, with a low-pressure cylinder working at 750 lbs. per sq. in., and the high-pressure cylinder at 2½ to 3 tons per sq. in. High and low pressure accumulators of the box-type are provided. The pressure exerted on each flag is from 500 to 600 tons. The capacity of the brick plant is 10,000 to 12,000 bricks per day of ten hours, that of the flag plant being 20 to 30 flags per hour. The whole is electrically driven by a 70 h.p. motor, and the labour employed working the brick and flag plant alternately is three men, two boys, and a foreman.

Automotor Water Wagon.

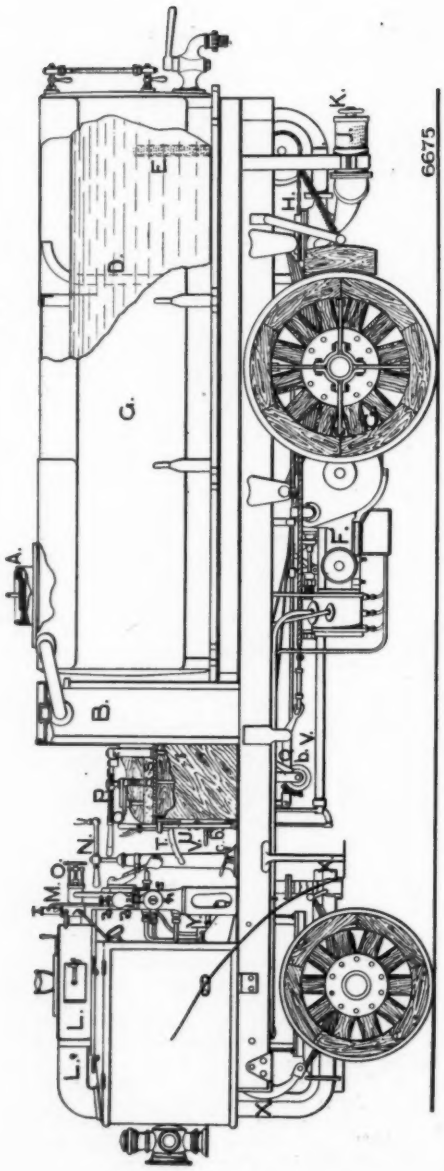
A MORE efficient appliance than the old horse-drawn water-cart for laying the dust has long been sought; and a happy solution of



"HERCULES" BRICK-MAKING MACHINE.

the problem has been arrived at by M. Bret, Ingénieur des Ponts et Chaussées, who is Chief of the Sixth Section of the Paris Municipal Service. He has applied a steel-plate water-tank of 5-cub. m. (1,100-gal.) capacity to a Dion-Bouton steam wagon, slightly modified, which, when the tank is removed, can at any time be used for ordinary haulage purposes. To the car has been fitted a pair of specially designed cylindrical boxes, into which the water is forced by a Farcot centrifugal pump, escaping through small holes perforated in the greater portion of the periphery of the boxes.

Referring to the accompanying illustrations, it will be seen that the front of the wagon is occupied by a vertical central-fired water-tube boiler with its smoke-box, flanked by coke bunkers, the smoke off-take being turned down under the frame, for diverting below any escaping smoke and steam, and for giving the appearance of a petroleum motor-car. Behind the boiler is the driver's seat, with easy reach of hand-wheel for steam stop-valve, reversing-lever, steering-gear, brake-gear, that for change of speed, that for working the extra power-cock referred to below, pedal for

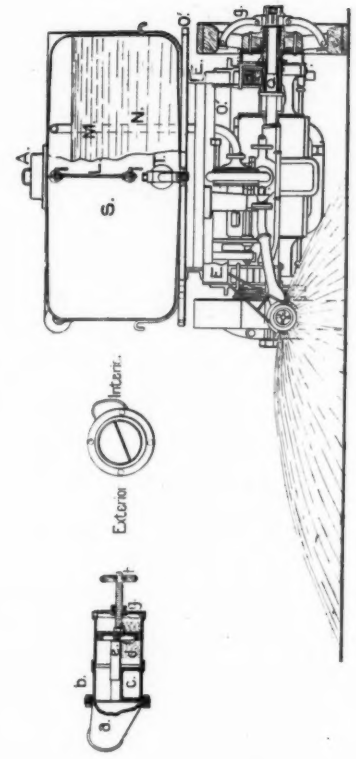


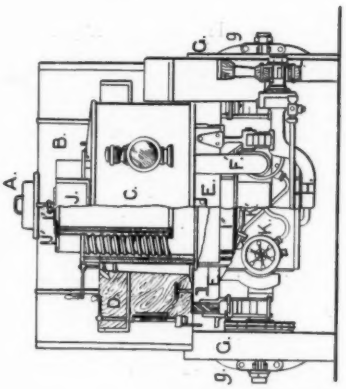
AUTOMOTOR WATER-WAGON.

A. Man-hole.
B. Feed-water tank.
D. Waste pipe from centrifugal pump.
E. Wind-bore of centrifugal pump suction pipe.
F. Steam motor.
G. Reversible watering tank.
H. Cock for water distribution.
L. Centrifugal pump.
J. Watering box.
K. Hand-wheel for working do.
L. Smoke-box.
M. Safety-valve.
N. Steering handle.
O. Steam stop-valve.
P. Lever for working water-distribution cock *H*.
Q. Handle for putting on shoe brakes *d*.
R. Donkey feed-pump.
S. Driver's seat.
T. Reversing lever.
U. Cylinder pet-cock gear.
V. Cock for admitting high-pressure steam into low-pressure cylinder.
X. Smoke off-take.
Y. Steam boiler.
a. Handle for effecting change of speed.
b. Pedal for strap brake on shaft of differential gear *B*.
c. Pedal for throwing in the pump-gear.

throwing in and out the centrifugal pump, and also a lever for working, through rods and links, a special cock, placed under the hind carriage, for admitting water from the pump to one or both of the cylindrical boxes, quite in the rear. Underneath the floor, at about the middle of the wagon's length, is a 35-h.p. horizontal compound steam-engine, exhausting into the smoke off-take, and which, acting through differential gear on the seat axle, gives the fully-loaded wagon, weighing 6 tons, a speed of 15 kms. (9 mls.) an hour on the level, or of 4 to 5 kms. (say 3 mls.), when mounting a gradient of 1 in 10. The large cylinder is fitted with a cock for admitting steam at boiler pressure, thus giving extra power, in case there should be difficulty in starting or mounting a gradient.

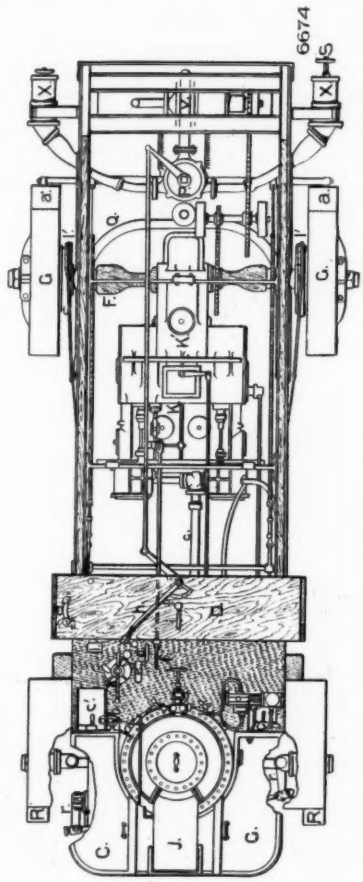
Inasmuch as, owing to the bearing springs, the frame, and also the engine, is subject to vertical displacement, with respect to the wheels, the driving shaft is connected with the axle by a Cardan joint, which affords the necessary amount of play. The interposition of a link between the two parts of the driving shaft allows these to move slightly without interfering with the rotation, the heads being free to oscillate in the grooves in the boxes at the ends of the two





WATERING BOX WITH ADJUSTABLE DELIVERY.

a. Conical adjutage or leading up the water.
b. Body of box.
c. Portion inaccessible to the water.
d. Conical and cylindrical holes for escape of the water.
e. Plate for directing the water.
f. Regulating piston.
g. Movable cover with bayonet joint.
h Hand-wheel for working piston.



AUTOMOTOR WATER-WAGON.

A. Man-hole.
B. Feed-tank.
C. Coke bunkers, with slides *C'*.
D. Water-tube boiler.
D'. Trap-door for loading coke.
J. Smoke-box ; *J'* Register gear ; *J''* Smoke off-take.
K. Motor and spur-gear casing.
N. Wind-bore of suction pipe.
O. Steam stop-valve with hand-wheel.
P. Water-distributing cock.
R. Steering wheels with directing rods.
S. Movable tank.
S'. Hand-wheels for working piston of watering boxes.
V. Centrifugal pump.
X. Watering boxes.
h. Feed injector.
c. Rod for working pet-cocks.
d. Cock for admitting high-pressure steam into low-pressure cylinder.
e. Pedal for throwing pump into gear.
h. Gear for working the water-distribution cock.
i. Change of speed gear.
j. Donkey feed-pump.
l. Pedal for working strap-brakes *l'*.

parts of the driving shaft. In order to permit of this displacement, and cause less strain on the wheels, the journal is made hollow ; and the driving shaft traverses it freely. The wheel-boss is not fixed on the driving shaft, but is drawn round by a special part fixed to its end, and provided with four arms, fitted to the ends of the spokes against the rim, as shown by the drawings.

The watering-boxes, an enlarged detail of which is given, contain pistons, the position of which can be regulated from the outside by screw and hand-wheel, for varying, in accordance with requirements, and especially according to the state of the weather, the number of holes through which the water can pass. Owing to the action of the centrifugal pump, the water is projected with considerable force, so as to cover a large width of road, as shown in the rear-end view ; and the amount of watering, regulated as above described, is always proportional to the speed of the wagon, no matter how irregular, because the pump is driven by multiplying chain and sprocket gear off the hind axle. The water-distributing cock has several ways for permitting the driver, from his seat, to admit water to, or exclude it from, one or both boxes, or to reduce the volume admitted, and consequently the width of road watered, without altering the speed of the wagon, and therefore of the pump, the surplus water being returned to the tank by a pipe of small section, so as not to reduce the pressure too much. In front of the main tank, communicating with it, is the boiler feed-tank ; and the two are filled together by hose from the water service.

The wagon is at present used in the Place de l'Étoile, where stands the Arc de Triomphe, and in the Avenue du Bois de Boulogne, where the speed of the carriages is about 9 km. (5½ mls.) an hour. At this speed, which has been adopted as the normal for watering, the tank discharges its 5 cub. ms. (1,100 gals.) in about 8 mins., while watering a road width of 9 to 9·5 ms. (say 10 yds.), with the boxes only open for three-fourths of their capacity. The watering thus obtained is at least as effectual as that afforded by horse-drawn water-carts ; and one day's work of the automotor wagon is equal to that of four or five one-horse carts containing 1,200 litres (264 gals.).

M. Bret, and also the makers, M.M. de Dion et Bouton, of Puteaux, Seine, are to be congratulated on the successful results achieved by this new municipal appliance.

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Improved "Pop" Safety-Valve.

By the courtesy of Mr. H. A. Hoy, M.Inst.C.E., formerly locomotive superintendent of the Lancashire and Yorkshire Railway, we are able to illustrate and describe an improved duplex "Pop" safety-valve recently designed by him.

It will be seen by the drawing that the "Pop" ring is similar to what is usual in this form of valve, excepting that it can be adjusted so that the knife-edge bears up to the seating. This is done to meet the difficulty in valves of this description, as usually constructed, of adjusting the knife-edge to the seating of the valve, especially after grinding in.

A number of small holes are made in the seating, opening into the annular space between the knife-edge and the main seatings of the valve. These holes lead into circular chambers, which are connected together by a cross-core. If one of the valves should lift somewhat before the other, part of the escaping steam travels across and, accumulating in the annular space, assists to raise the other one. This results in the valves opening and closing together.

A screw-down valve is screwed into the cross-core for the purpose of regulating the "pop" action by determining to a nicety the pressure of the steam accumulating in the annular space inside the "pop" rings of the valves. In practice the screw-down valve is set so that the limit of "pop" action is 2 lbs. per sq. in. above the nominal boiler-pressure, and the valves close when that pressure has been reduced to 2 lbs. per sq. in. less than the nominal boiler-pressure.

The seatings are made of gun-metal, and they bear only on the periphery of the lower portion, so as to prevent their upper portions being distorted by the unequal expansion of the cast-iron base.

The adjusting screws can be protected from being tampered with by the special arrangement shown on the drawing. The small dome-cover is made with a recess which is filled with lead, and this prevents the cover being removed until the lead is removed by a trepanning tool.

These safety valves are made by Messrs. Beyer, Peacock & Co., Ltd., Gorton Foundry, Manchester.

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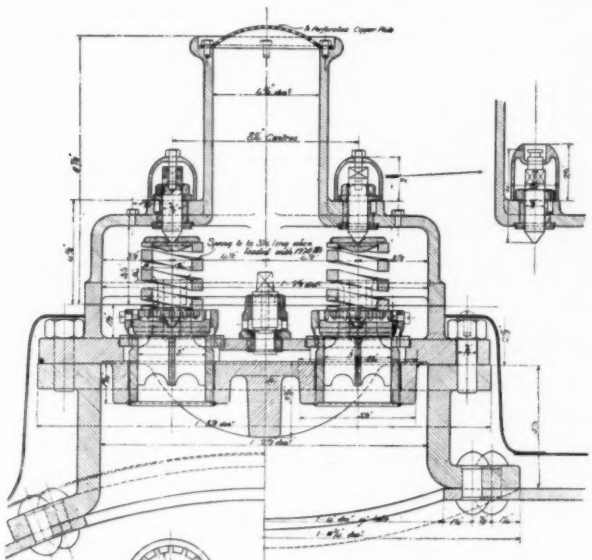
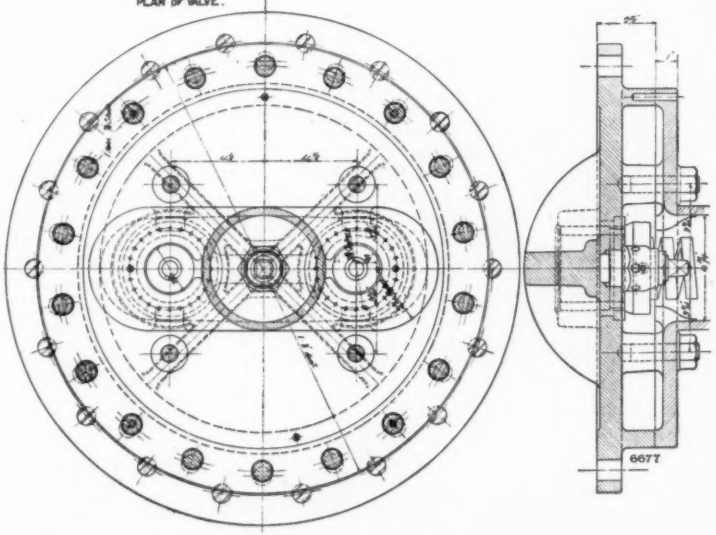
Ferro-Concrete Bow-String Bridge.

The ferro-concrete system of construction is now so generally known and appreciated



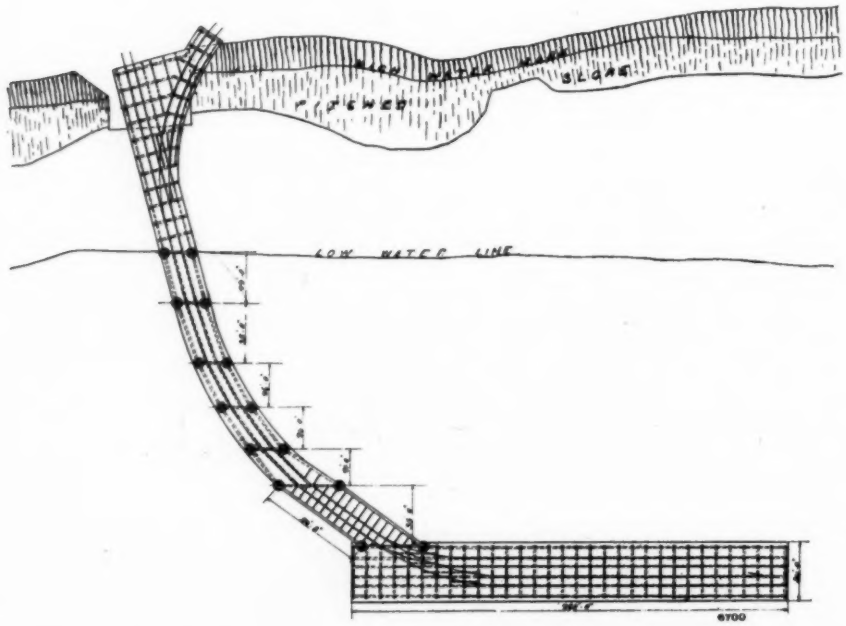
PLAN OF VALVE.



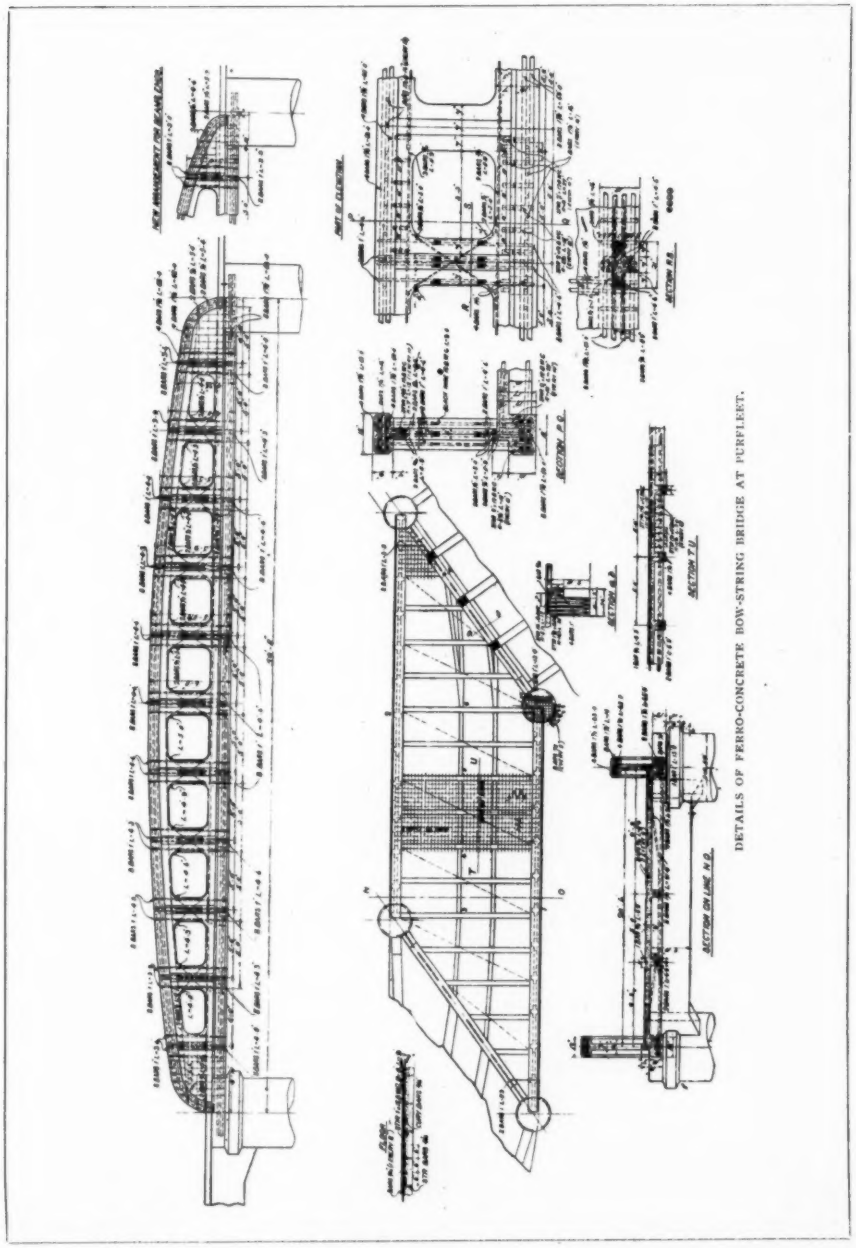
IMPROVED "POP" SAFETY-VALVE.

by engineers for almost every class of work that it is hardly necessary to refer to the details of the general principles on which it is based. A recent example of bridge construction on this system, consisting of the new jetty and pier at Purfleet, is of particular interest, and is illustrated herewith. The work in question was constructed in Hennebique ferro-concrete by Mr. L. G. Mouchel from the designs of Messrs. P. W. & T. S. Meik, the contractors being Messrs. C. H. Walker & Co., Ltd. It consists of an approach, one skew span of 60 ft., and the jetty or pier-head standing well out into the river. As will be seen from the plan the approach is curved, but the openings have been so constructed as to be square to the current of the river. The bridge proper is constructed on the bow-string principle to permit the required head-room beneath for the passage of barges at H. W. S. T. Each girder measures 59 ft. 8 ins. in length, and is 6 ft. deep in the middle of the span, the upper chord being 18 ins. wide by 9 ins. deep. It is reinforced longitudinally by 8 round bars $1\frac{3}{8}$ ins. diameter, cross-bars serving to check any tendency to lateral bulging. The lower or tension member is also stiffened by round bars, which are connected by stirrups placed at intervals of 10 ins. The vertical members are cross-shape in plan, and are strengthened by vertical bars having hooked ends connected with the main bars of the upper and lower members. The decking, which is also of ferro-concrete, is 5 ins. thick, the cross girders being 15 ins. deep by 8 ins. wide. The bridge carries a single line of standard gauge laid on ferro-concrete rail-bearers. The several details of the reinforcement are plainly shown in the accompanying drawings, from which it will be seen that provision has been made to bind the concrete together in both transverse as well as longitudinal directions.

With regard to the pier, this, in the main, has been built up of ferro-concrete beams carried on, and bonded with, piles of the same construction, with the exception of those on the outside which are of wood. All the foundations have been made in the same manner, the cylinders, decking, and bracing being moulded on to and intimately



PLAN OF NEW JETTY AND PIER AT PURFLEET.



DETAILS OF FERRO-CONCRETE BOW-STRING BRIDGE AT PURFLEET.

connected with the head of the piles, so that the structure is practically monolithic, and made as if at one time in one large mould.

A test of the bridge was carried out recently, the load consisting of two bogie trucks, each loaded with 30 tons of rails, making a total of 60 tons in all. The load on passing over the bridge caused a deflection reaching a maximum of only $\frac{5}{32}$ of an in., which is less than $\frac{1}{7000}$th part of the span, a remarkable result when the small depth of the bottom members of the bow string is taken into consideration. The total weight of steel in the structure is 15 tons.

Pumping Plant for the Coolgardie Water Supply.

IN a previous number* we placed before our readers some preliminary details concerning the Coolgardie Water Scheme. These chiefly related to a description of the water-carrying pipe, the unique features of which rendered the undertaking possible to be carried out at an exceptionally low figure. We are now, however, in a position to give some particulars of the pumping plant that is now in successful operation there. Before proceeding to a description of this, however, we may refer briefly to the project itself.

The Coolgardie Goldfields are situated some 363 mls. from Freemantle on the west coast of Australia, and are comprised within an area which is practically waterless, the average rainfall being 7·14 ins., and the evaporation 82·6. The difficulty of working the gold in early days, together with the ill-health due to the shortage of water, led the Government to undertake a scheme for a supply of fresh water to the goldfields by means of pumping from the coast. The main supply reservoir has been established in the Darling Ranges, about 30 mls. from Perth, and 320 ft. above the sea level, where two granite arms project across the valley, at the bottom of which, flows the Helena River. A concrete dam has been built up between these arms, thus closing up one part of the valley as shown in the accompanying figure. The dam is 760 ft. long and 100 ft. high in the deepest part, and the foundation is carried down nearly 100 ft. below the river-level. At the base, the dam varies in thickness from 65 to 130 ft., tapering to a width of 15 ft. on the top. The reservoir thus formed is eight mls. long, and has a capacity of 4,600,000,000 gals. of water. The catchment area consists of 850,000 acres.

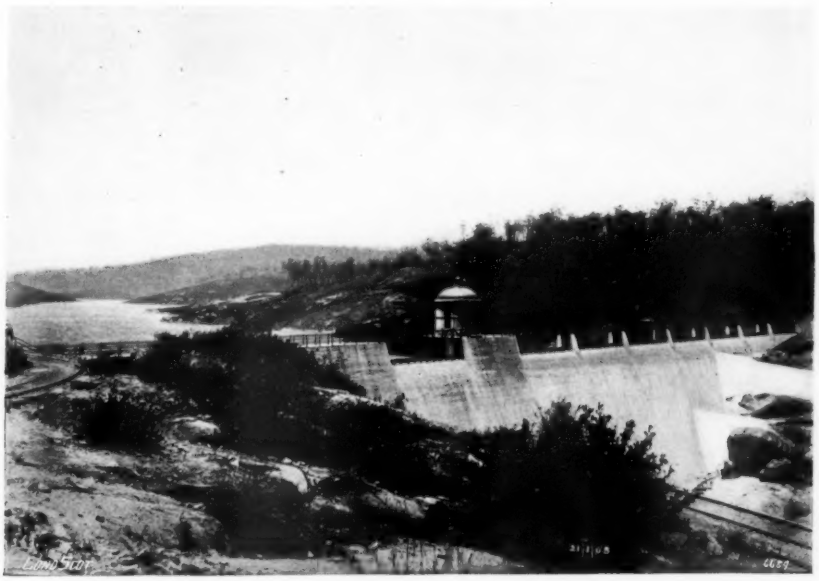
* Vol. II., p. 555 to 563.

As the whole scheme depended on mechanical means for the forcing of the water through the pipe-line, the question of the type of pumping machinery to be used was gone into most carefully. Briefly, the problem was to pump 5,600,000 gals. per 24 hrs., against a total estimated head, including friction, of 2,700 ft., through a pipe 30 ins. diameter and roughly 330 mls., the speed of the water through the pipe to be taken at 2 ft. per sec. Eight pumping-stations in all, separated by varying distances, were constructed, anyone of which is capable of pumping 2,800,000 gals. per 24 hrs., against a head of 450 ft. The first station is situated close to the foot of the Helena dam, and elevates the water 421 ft. into an open concrete tank of 468,000 gals. capacity, situated at No. 2 station, the intervening length being 1½ mls. From No. 2 station the water is pumped up 360 ft. through 23 mls. of mains to a concrete regulating tank of 500,000 gals. capacity, situated 1,080 ft. above sea level. From this spot the water runs by gravity to a second 500,000 gals. concrete regulating tank 18 mls. further on, which is 94 ft. lower than the first. Still falling the water continues to a distance of 78 mls. from Helena Reservoir to a 10,000,000 gals. capacity tank at Cunderdin. Stations 3 to 7 pump the water against a steady rise to the 8th station, situated 217 mls. from Cunderdin at an elevation of 1,457 ft. Thence the water is pumped 12 miles to the main service reservoir, of reinforced concrete and 12,000,000 gals. capacity. From this a small service reservoir of 1,000,000 gals. capacity, overlooking the town of Coolgardie, is supplied, the mean elevation being 1,525 ft. The total head pumped against in the daily working of stations Nos. 1 to 4 varies from 360 to 410 ft., and at stations 5 to 8, 180 to 210 ft. From the service tank the water flows by gravity to the reservoir of Mount Charlotte which is to supply the town of Kalgoorie. After careful enquiry the contract for pumping machinery was placed with Messrs. Jas. Simpson & Co., Ltd., of London, a special clause being inserted in the contract giving them permission to have half the manufacturing work done by the Worthington Pumping Co. The tender was not the lowest, but the complete nature of the proposals made, and the economical results guaranteed in working, decided the Government to pay the higher price. Twenty 300-i.h.p. engines, all of the triple-expansion high-duty Worthington type, were provided, the only difference in the individual engines being that eight of them had 21-in. water-plungers, and twelve had 15-in. The whole of the steam ends are standard to one size, a point which meant

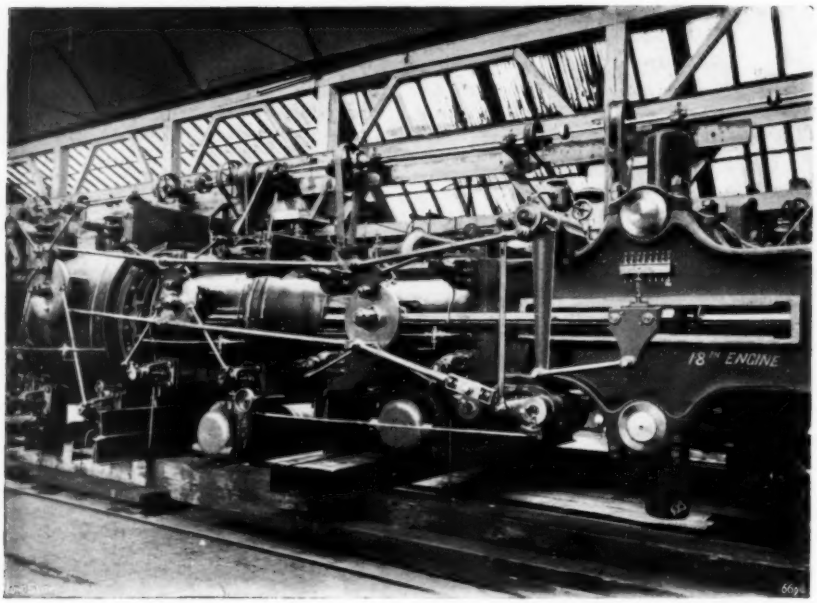
an economic gain, as the whole of the boilers and the accessories could also be made standard, and the number of spare parts consequently reduced. The steam ends of each engine consist of two 16-in. high, two 25-in. intermediate, and two 46-in. low-pressure cylinders, all of which, including the covers, are steam-jacketed. Intermediate reheaters, with steam at boiler-pressure, are used between both ranges of cylinders. The air-pumps are placed below and between the steam and water ends of the engine, and are driven by links and levers from the cross-heads. The water-ends are of the Worthington outside-packed plunger type, fitted with a steel air-vessel on the delivery, and a cast-iron air-vessel on the suction. The condenser is placed on the suction, so that the whole of the water of the main passes through the condenser; and, as the volume is largely in excess of what is actually required, the temperature of the water in the main is not raised to any appreciable extent. The efficiency of the Worthington high-duty engine is attained by a special attachment, by means of which the excess of power exerted by the steam in the cylinders at the beginning of the stroke is stored up and utilised at the end of the stroke when the steam pressure owing to expansion is at a minimum. This attachment also forms a safeguard in the event of a breakdown occurring on the delivery main. The engines have also been fitted with an automatic vacuum breaking apparatus, so arranged that, when the pressure in the main falls below or rises above a pre-arranged limit, it immediately comes into action and opens a valve on the exhaust pipe to the atmosphere and the engine stops immediately. The main pumps of each engine consist of two sets of double-acting plungers working on the Worthington cycle by which an almost uniform delivery is obtained and shocks are entirely avoided. An ingenious arrangement for using the steam jacket has been carried out. As the steam passes from the jackets it is used to drive the feed pumps, the exhaust from these being utilised in a Webster Feed Water Heater. The feed water is thus sent along to the Green's Economiser at a very high temperature.

The boilers are by Babcock & Wilcox, with single drums and equipped with superheaters Webster feed-water heaters, and Green's Economisers.

The contract between Messrs. Simpson and the Western Australian Government, provided that each of the pumping-engines



COOLGARDIE WATER SCHEME: THE HELENA DAM.



COOLGARDIE WATER WORKS: ONE OF THE WORTHINGTON ENGINES WITH HIGH-DUTY ATTACHMENT.

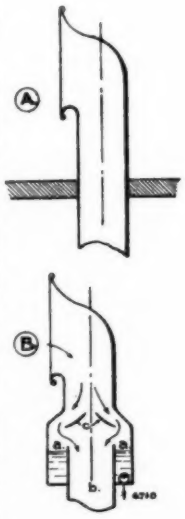
should be capable of attaining throughout a 12 hours' trial a duty of 135,000,000 foot pounds of effective work per 1,000,000 B.T.U. supplied to the engine, which would not be returned to the boiler in the ordinary course of working, and also that, for the purpose of testing the combined working duty of the pumping-engines and boilers, two groups of machinery at one of the first four stations, and one group of machinery at one of the second four stations should be capable of pumping through the main to the next reservoir not less than 2,800,000 gals. of water during a 12-hr. trial; and that the combined duty of the group should throughout such trial amount to at least 135,000,000 foot-pounds of effective work for every 160 lb. of coal consumed, such coal having a calorific value of 10,000 B.T.U. per pound.

In the test the 1,000,000 B.T.U. gave a duty of nearly 143,000,000 foot-lbs., whilst the work obtained from each 160 lbs. of coal consumed, reached 144,427,000 foot-lbs. in one test, and 148,141,000 in another test. The amount of water pumped by the two groups of engines, was 2,998,081 gals, being an excess of 198,081 gals.

Improved Ship Ventilator.

IN the ordinary ship ventilator, shown by *A* in the accompanying sketch, the air-current descends when the ventilator is turned towards the direction of the wind and ascends, by induction, when turned in the contrary direction. It is necessary to close the ventilator in rough weather, thus suppressing the ventilation, in order to prevent the seas that are shipped from inundating the saloons.

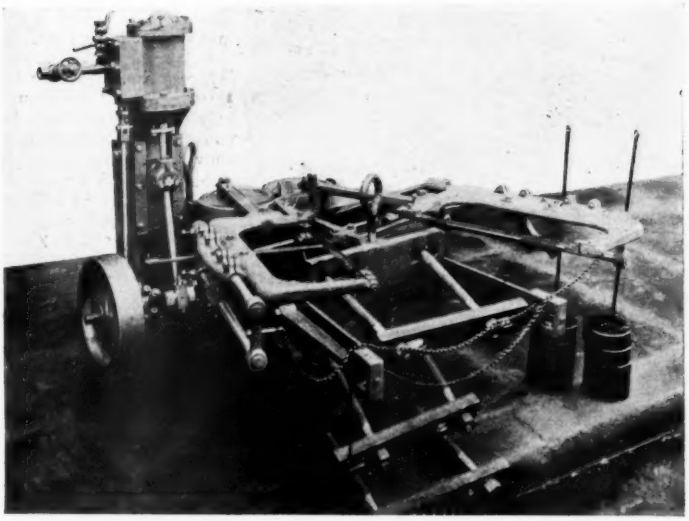
In the improved form of ventilator *B*, brought by M. Van de Wyer before the Antwerp Section of the Liége Engineers' Association, any water entering is intercepted by the annular



IMPROVED SHIP VENTILATOR.

reservoir *a a*, whence it is led by a pipe on to the deck, without interfering with the free passage of the descending air-current, the angle of the cone *c* being calculated so as to oppose the least resistance.

In some experimental trials made on board a vessel provided with these improved ventilators, a registering anemometer placed at the point *b* shewed a practically constant speed, even when two fire-hose played upon the mouth of the cowl.



SPECIAL HACK SAW MACHINE.

Special Hack Saw Machine.

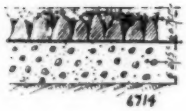
THE accompanying illustration is that of a novel hack saw machine specially designed and constructed for use in connection with the building of a pier. It will be seen that it is furnished with two reciprocating saws, which are worked by compressed air by means of a small high-speed engine, with 4-in. by 8-in. cylinders, working at 120 revolutions per minute, which is reduced by cut direct gearing to 60 strokes per minute. It is being used for the purpose of cutting off level the ends of upright steel-piles after they have been driven in position. Previous to the employment of this machine the piles were drilled off, and afterwards dressed with pneumatic chipping hammers. The machine does the work much more satisfactorily, and in a fraction of the time previously occupied. Eye-bolts are provided, by which the saw is slung from pile to pile, as required, it being cramped on by means of the bolts and straps shown in the illustration. When not required on pile work the machine can be placed in the shop, standing on a base provided. The engine then works horizontally, either by steam or air, and the saws, working vertically, can be used for cutting off girders, etc., to dead lengths. The makers are Messrs. Beanland, Perkins & Co., Ltd., of Leeds.

Granite-Asphalte.

A New Materal for Road Construction.

A NEW material for street construction, which should prove of interest to all municipal engineers, has been, for some time past, undergoing practical tests in Paris with results which appear to demonstrate its superiority over existing methods employed there.

The main problem was to find a means of eliminating the disadvantages attaching to the use of natural asphalte, by modifying its composition. This object has apparently been attained by a mixture to which the name of granite-asphalte has been applied, and which has revealed, in the tests which it has undergone, qualities which point to its suitability as a road-facing in thoroughfares over which there is a very heavy traffic. This result has been obtained by the incorporation of mineral matter, granite particles in particular, under certain conditions of temperature and handling. The mixture is treated in precisely the same boiler as is used for asphalte, and at a given temperature a reaction is said to take place which, together with the subsequent treatment, causes



GRANITE-ASPHALTE.

a modification of the original physical and chemical properties of the composition. Granite-asphalte is stated to be capable of resisting the dissolving action of acids, oil and fats which rapidly attack ordinary asphalte.

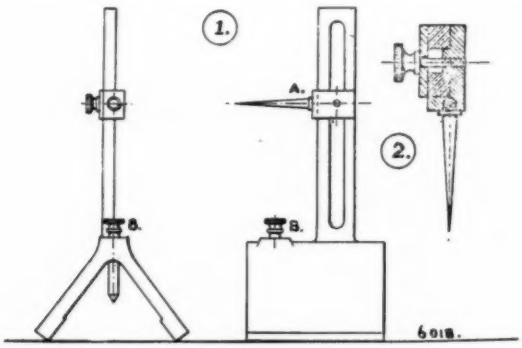
From the physical point of view, granite-asphalte paste manifests a particular hardness, and by reason of its high resistance to wear may be classified with granite and other hard stones. Wear takes place very regularly, the granite grains adhering so closely to the asphaltic gangue that it was found impossible to separate them in any of the breaking tests to which it was submitted. It provides a surface which does not become slippery, and does not soften under the influence of solar heat.

In practice, the paste is poured over a layer of small granite pyramids which are spread over a thin bituminous layer, in turn adhering to a concrete foundation. To this construction, a vertical section of which is shown in the accompanying figure, the name *asphalte armé*, or armoured asphalte, has been applied. The thickness of the superincumbent layer varies with the nature of the traffic from 4 cm. to 7 cm.

There is little or no tendency to slip, a quality which renders the employment of this material possible on gradients on which up to the present it has been the custom to use only ordinary setts. For example, it has been satisfactorily employed on one of the ramps leading to the Paris goods-station of P. L. M., in which there is a rise of 3 cm. per metre, and a curve of 8 m. 50 radius. Further extensive applications of the method have been made in Paris and at Belfort, the exploitation of which is, according to *Le Génie Civil*, in the hands of the Société de L'Asphalte Armé.

Gauge for Testing Weigh Shafts.

THIS gauge consists of a cast-iron body, the lower part being V-shaped, for the reception of the shaft. The upper part has a vertical slot, in which slides the block carrying a fixed steel needle *A*. The general arrangement of gauge is shown in Fig. 1, and the details of clamping arrangement are shown in Fig. 2. In the lower part a steel pin *B*, having a sharp point, slides vertically, the axis of the pin equally dividing the angle of the V. This line, produced upwards, would coincide with the line traced out by the needle *A*, in sliding down the vertical slot. When testing the position of the lever, the centre of the pin is found and marked on the end. The gauge is set on the shaft, and the needle *A* is adjusted to the height of the centre. The pin *B* is then set with its point on the centre line showing the position of the lever on the shaft. The amount of error is shown by the distance between the point of *A* and the centre of the pin. E. H. D.



TESTING WEIGH SHAFTS.

RAILWAY NOTES.

Walschaert Valve Gear on the Great Northern Railway.

THE Walschaert valve-gear, so popular in Continental locomotive practice, has not hitherto found much favour with British designers.

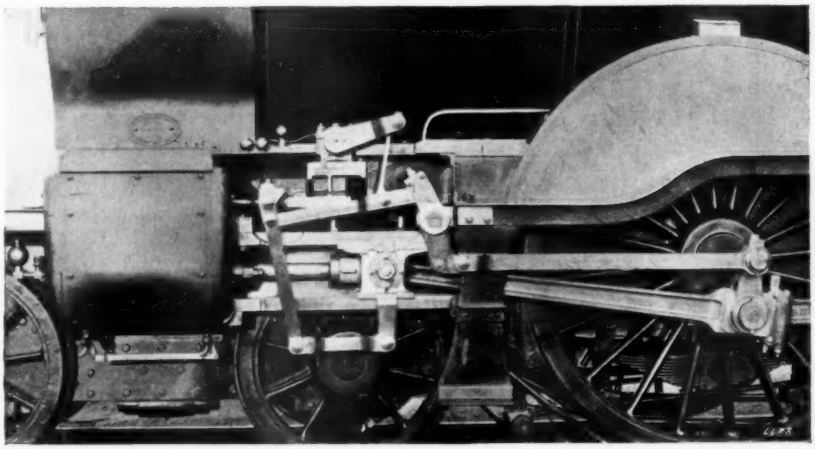
Quite recently, however, Mr. H. A. Ivatt, of the Great Northern Railway, has fitted the Atlantic type 4-cylinder engine No. 271 with this gear on the outside cylinders, the arrangement being shown in the accompanying illustration. The engine in question was built at Doncaster in 1902, with four cylinders arranged in line, two outside and two inside the frames below the smoke-box, all driving on the first axle. The engine is not a compound ; all four cylinders use high-pressure steam.

In September of this year, however, the engine was fitted with new cylinders of the same dimensions as before, viz., 15 ins. diameter by 20-in. stroke, but cast with their valve-chests on top. The gear was also altered, so that the engine has now four sets, the Walschaert type being applied to the outside, and the Stephenson, with a rocking shaft, to the inside valves.

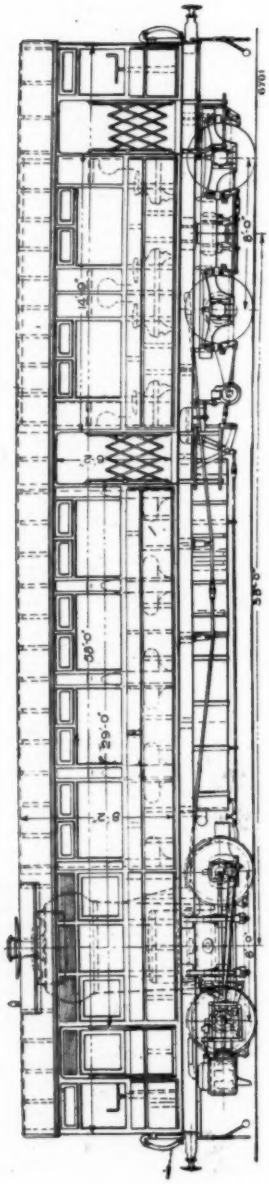
Steam Motor Car, Great Northern of Ireland Railway.

Continuing our description of the various motor carriages that have been recently placed in service by some of the leading railway companies, we select, this month, the type adopted on the Great Northern of Ireland Railway, of which one is actually in service and three others are under construction. These cars are intended for working the local branches between Dublin and Howth, and Belfast and Lisburn. From the specification forwarded to us by Mr. Henry Plews, the general manager, the following particulars have been selected.

The engine and boiler are carried on a four-wheeled bogie with wheels 3ft. 7 ins. diameter, placed 8 ft. apart centre to centre. The cylinders are 12 ins. diameter by 16 ins. stroke, fixed horizontally on the outside of the bogie-frames, and drive the trailing pair of wheels, which are coupled to the leading pair, the valve gear being of the Walschaert type. The boiler is of the vertical multi-tubular type, with cone top and 4 ft. 5 ins. diameter inside at bottom, and 5 ft. 11 ins. diameter inside at largest ring, and 9 ft.



GREAT NORTHERN RAILWAY ENGINE, NO. 271 : VIEW SHOWING THE WALSCHAERT VALVE-GEAR.



STEAM MOTOR CAR, GREAT NORTHERN OF IRELAND RAILWAY.

6 ins. high. It works at a pressure of 175 lbs. per sq. in. The firebox is in one plate, $\frac{1}{2}$ in. thick, 3 ft. 10 ins. diameter inside, and 3 ft. 6 ins. high, stayed to barrel by two rows of Stone's bronze flexible stays 15-16 in. diameter screwed into both plates and riveted over with full-size heads. They are pitched 12 ins. vertically, and $4\frac{1}{2}$ ins. circumferentially.

The tubes are of steel and number 479, and are placed $1\frac{13}{16}$ in. centre to centre. They are $1\frac{3}{8}$ in. diameter outside, and are No. 14 B.W.G. thick.

The height from rail to top of chimney is 13 ft. 2 ins.

The cylinders are 12 ins. diameter by 16 ins. stroke, and are attached outside the frames, 7 ft. $1\frac{1}{2}$ ins. apart. The engine and car are fitted with the automatic vacuum brake, so arranged that it can be applied and released from either end of the car. The car also has hand-screw brakes, which can be operated from either end.

The cars have three compartments and two vestibules; motor compartment, 13 ft. 9 ins. long; third-class compartment, 20 ft. long; vestibule, 2 ft. 9 ins.; first-class compartment, 14 ft.; end vestibule 5 ft. 6 ins. long. The motor end is suspension-hung from the engine bogie-frames, and the vestibule end carried on a four-wheel Fox's pressed-steel bogie with 3-ft. 7-in. wheels. The bogies are placed 38 ft. centre to centre, and the body is 58 ft. long by 9 ft. 6 ins. wide outside over pillars, curved in to 9 ft. at the bottom sides, 8 ft. 2 ins. high inside at the centre. The underframe, of best mild steel, is 58 ft. long over the headstocks by 8 ft. 7 ins. wide, set out each side to 9 ft. at the motor end.

The water-tank placed under the car is 18 ft. 4 ins. long by 2 ft. $7\frac{3}{4}$ ins. wide by 1 ft. 10 ins. deep inside, made of $\frac{1}{8}$ in. mild-steel plates, with flanged ends and splash-plates. As regards the body of the cars, the bottom sides and end bars are of teak, 10 ins. by $3\frac{3}{4}$ ins. thick.

The entrance to the vestibules each side are fixed with collapsible gates and long commode handles fitted each side at vestibule entrance and motor compartment. The motor compartment has sliding-doors 2 ft. 11 ins. wide each side. The internal decorations are of wood, in excellent taste, and the seats are well upholstered and on wire sofa-springs.

In the first-class, the lower part of the sides is cased with vertical walnut matching, and 6-in. walnut skirting, the upper part panelled out in oak with walnut mouldings, the panels between the lights over the seats having bevelled-edge mirrors in walnut frames.

In the third-class compartments the casing

is ⅞ in. thick, V-jointed, the partition having parcel-racks made of pitch-pine laths, and rods carried by brackets to pattern. The windows are fitted with tapestry balanced blinds.

The cars, including the head and tail lamps, are lighted on Stones 24-volt double-battery system. The head and tail lights have one 8-c.p. lamp each, and the wiring is so arranged, that the switching on of the head-lights can extinguish the tail-lights, and the switching off the head-lights can light the tail-lights. Gold's steam-heating is fitted to the cars, each compartment having storage-heaters under the seats. An electric-bell communication is also fitted between the vestibules and motor compartment, the bell being placed in front-end of motor compartment.

2-6-0-type of Locomotive with Superheater.

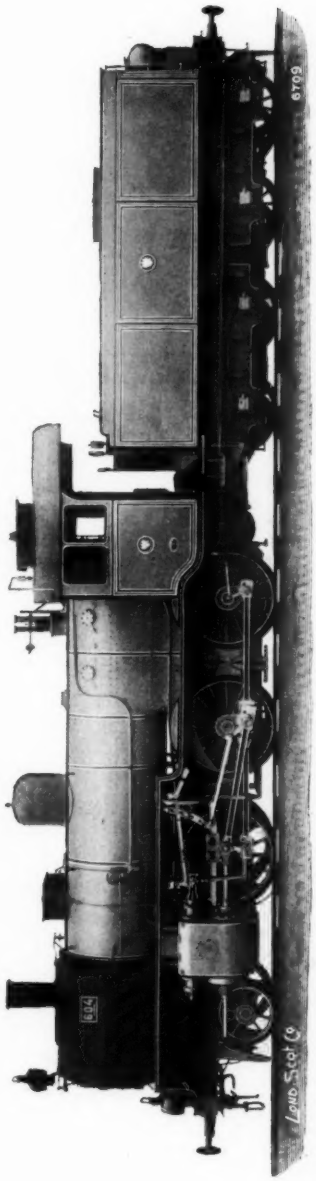
By the courtesy of the builders, the Berliner Maschinenbau-Actien-Gesellschaft, we are enabled to give some leading particulars and illustrations of an interesting type of superheated steam locomotive intended for fast traffic on the heavy lines of the Royal Prussian State Railways.

It is of the six wheels coupled type, and has a leading Bissel-truck of the "Krauss" system, which arrangement gives a large adhesive weight, and at the same time an easy running over curves, as in the case of bogie-engines.

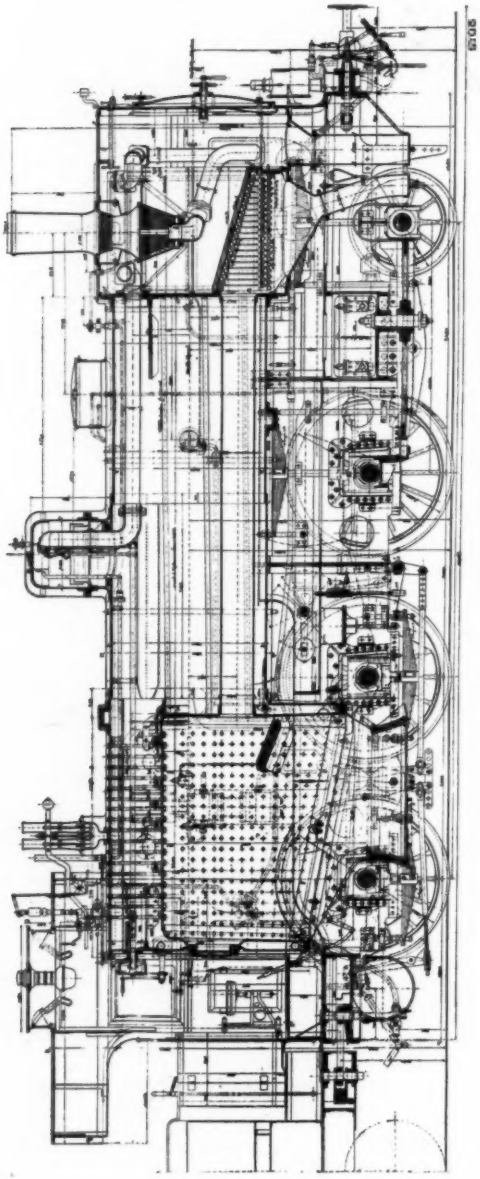
The engine is of simple expansion, and has outside cylinders. The motion is of the "Heusinger" type with piston-valves of 150 mm. diameter. In the smoke-box is fitted a Schmidt superheater, in which live steam is superheated before entering the cylinders up to 570–660 degs. Fah. The superheater consists of bunches of pipes, bent to the shape of the smoke-box shell, and ending in two steam chambers in top of smoke-box.

The superheater is heated by gases of very high temperature, 1470 - 1830 degs. Fah., issuing directly from the grate through a flame-tube of 305 mm. diameter.

This arrangement of superheater has itself proved very satisfactory on all locomotives fitted with it, and has given, as regards economy, such excellent results, that on the lines of the Prussian State Railways the use of superheater locomotives is rapidly increasing. Trials were made during several months with this Mogul superheater-engine with regard to the speed efficiency, and economy in goods service as well as in the heavy mountain-express service. It has



2-6-0 TYPE LOCOMOTIVE WITH SUPERHEATER FOR PRUSSIAN STATE RAILWAYS.



2-6-0 TYPE LOCOMOTIVE WITH SUPERHEATER FOR PRUSSIAN STATE RAILWAYS.

proved itself superior to an ordinary Mogul locomotive of the same weight, and also to a four-cylinder compound ten-wheeler of 15 tons heavier weight.

The average saving as regards water amounted to 18–20 per cent., on coal 12–15 per cent.; also the cost of maintenance and repairs were less.

The superheater-engine hauled, on a line 77 mls. in length, with many curves, and with grades of 1·100, an express train of 42 axles, *i.e.*, 322 tons, and a total weight of engine and tender of 424 tons, at an average speed of 65·3 mls., and the running of the engine was quite smooth. The average cut-off in the cylinders at this trial amounted to 23 per cent. The special advantage of this engine consists in its ability to start away quickly, even with the heaviest trains: a feature, which, in the opinion of the makers, points to the advantage of superheating.

All parts coming into touch with superheated-steam, as pistons, piston-valves and stuffing-boxes, behaved well in working, as did also the superheater.

The average temperature of the steam was 626 degs. Fahr. The steam pressure was throttled down to nine atmospheres in the steam-chest of the cylinders, so that there was an abundance of steam in the boiler during the whole trial-trip.

The engine is fitted with pneumatic sanding apparatus on the Brüggemann system, and with a speed-indicator on the Haushälter system. Pistons and piston-valves are lubricated automatically by means of oil-presses.

The Simplon Tunnel.

MR. FRANCIS FOX, writing in a recent issue of *Nature*, contributes some interesting information concerning the accuracy of the alignment in the boring of the Simplon Tunnel. Now that the International Meeting of Switzerland and Italy under Mont Leone may be shortly expected to take place, curiosity is naturally being aroused how far out the two borings will be at the destined meeting-point. The following steps have been taken to ensure accuracy.

The setting out of the centre line of the tunnel is done every month by the company and contractors, but, in addition to this, the work is checked several times in the year by the Government engineers. On these occasions the work in the tunnel is entirely suspended, so as to ensure that the atmosphere for the entire length shall be bright and clear. A small slit of light is thrown into the tunnel by means of a powerful lamp, and by the aid of theodolites this is taken right up to the working face. It is anticipated that when the actual meeting occurs the error in level will be nil, and that the error in direction will be under eighteen inches.

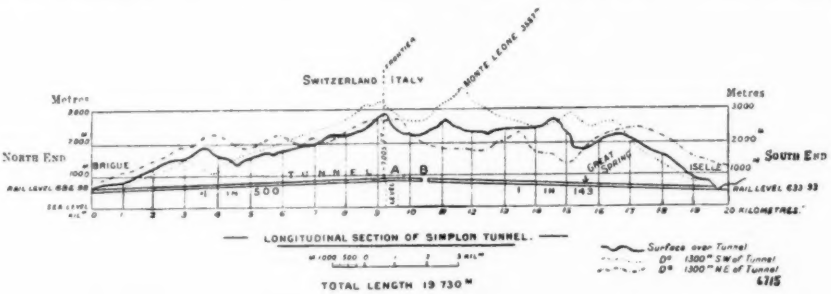
The length of the tunnel will be 12¼ mls., all of which has been penetrated with the exception of a short distance near the middle. The work consists of two single line tunnels 50 ft. apart, axis to axis, and the object of having two tunnels in place of one has been fully justified by later experience, and for the following reasons. The ventilation is much more efficient, one tunnel being used as an "intake" for fresh air, which is blown in by powerful high-speed fans working with a water-gauge of nearly 9 ins., the other being the outlet; in case of derailment of a train occurring it cannot possibly run into a train in the opposite direction; when repairs are required one tunnel can be closed for a time, the traffic being conducted in the other; and finally, which is most important, the crushing weight of the material overhead is much more easily dealt with than it would be in a double-line tunnel. When it is remembered that the overlying rocks extend to a height of 7,005 ft., and that the workmen are at the enormous distance of nearly 1½ mls. below the surface, or 50 per cent. more than man has ever been heretofore, it will be realised that not only is the pressure enormous, but the heat is also great; in fact, the pressure which has been encountered is so great that in one place the arching, consisting of granite blocks, is 2 m. in thickness. The tunnel is arched throughout, as it was deemed advisable that no risk should be incurred of even a small fragment of rock falling on to the permanent way.

In order that the present condition of the work may be better understood, a longitudinal section along the line of the tunnel is given.

It will be noticed that the gradient rises from each end of the tunnel towards the middle, the object of which has been to provide efficient drainage from the face. In driving a heading forward under a mountain, it is a matter of very common occurrence that springs of water are encountered; consequently, on the ascending gradient, the water flows away by gravity from the workmen; but should the work be carried out on a descending gradient, then the water accumulates where the men are working, not only causing them inconvenience and delay, but requiring to be pumped out over the highest point of the rails. In order to prevent delay, this was done for some considerable distance; but in consequence of a hot spring being encountered at the "face" on the Swiss side it was deemed necessary to withdraw the workmen, and the tunnel between points *A* and *B* has become filled with hot water.

The work of actual perforation at Brigue and Iselle began in August, 1898, by hand, and by Brandt drill in December, 1898. When, however, the advance from the Italian entrance had reached a point between 15 and 16 km., the great spring of 12,000 galls. per minute was encountered. This caused a delay of several months, thus throwing back the progress very considerably. In the meantime, the advance from Brigue proceeded rapidly, the summit *A* being reached in the month of December, 1903. Then arose the question, as already explained, in order to save time, of driving the tunnel downhill in order to meet the workmen coming up from Italy.

Meanwhile, the work on the Italian side has been pushed forward until the distance remaining



LONGITUDINAL SECTION OF SIMPLON TUNNEL.

to be pierced, as already mentioned, is only some 260 yds.; but a serious difficulty has arisen, for again a hot spring has been encountered, and the temperature of the rock in the advance gallery is 108 degs. Fahr.

The system adopted for dealing with hot springs is very ingenious—and at the same time very simple. It was at first proposed to conduct the hot water out of the tunnel through pipes; but the simpler and more efficient method, which was adopted, is to play a jet of cold water into the fissure from which the hot water is escaping, and thus to cool it down to such a degree that the workmen are not seriously incommoded; they are then able to continue the drilling and blasting.

A channel or canal is being excavated at one side of the tunnel to carry the hot water from the spring to the outside, and this will be covered over with non-conducting material to prevent the heat rising into the tunnel.

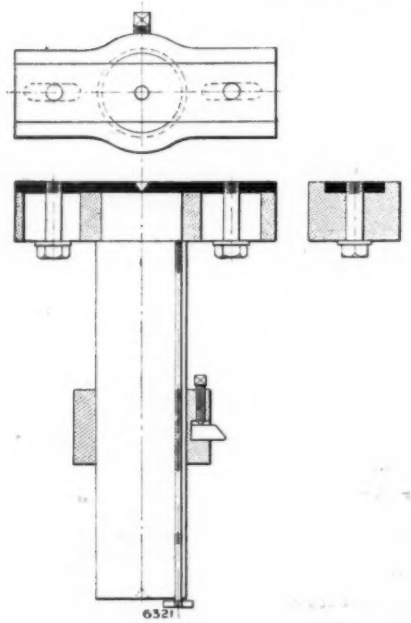
The question arises from whence this great heat comes, for although observations made in various wells and borings in all parts of the world give an approximate figure of 1 deg. Fahr. rise in temperature for each 70 ft. of vertical depth, this is insufficient to account for what has been encountered, and one is driven to that conclusion that some portion of the thermal result is due to the internal heat of the earth arising from volcanic agency.

It is expected that within three months of the piercement trains will be running, and the railway will prove to be a most important link in the line of communication between Rome, Genoa, and Milan with Lausanne, Berne, and Mid-Europe.

The Railway Round Lake Baikal.

ACCORDING to a German contemporary, this railway has now been completed, and since the 28th September, sixteen trains daily have been passing over it. The work was pushed on with the greatest activity by reason of the necessities of the Russo-Japanese war. On one section 25 km. in length, no less than 13 tunnels, representing a total length of 4 km. in had to be bored in difficult ground, chiefly rock. Electric drills were used, current for which was provided by a temporary power-house which also furnished the current for lighting and driving the pumps and ventilating fans. The erection of a steel bridge across the bay at Beresow, was carried out with great difficulty, owing to the violent storms which raged during the month of August.

Attachment for Taper Boring.



THE illustrations show a boring bar carrying a movable head and provided with the usual feed-screw. A cast-iron head is fixed on the end of bar; this carries a sliding steel plate held in position by a couple of set-screws passing through slotted holes in the casting and tapped in the steel plate, the latter being provided with a female centre. The sliding centre provides a ready means for adjusting to any taper, and can be graduated so as to denote the exact taper per inch. It has been used for boring taper-gauges, and for cartridge cases, as used in ordnance work; also for boring crank discs of large engines without removing them from shaft, the *exact* taper being determined with absolute accuracy.

C. R.

METALLURGICAL PROGRESS.

By PERCY LONGMUIR, Carnegie Research Scholar.

Steel.

Acid Open Hearth Manipulation. All interested in open-hearth practice will remember that Messrs. MacWilliam and Hatfield presented a paper to the Iron and Steel Institute in 1902 dealing with the elimination of silicon in the acid process. The results detailed in that paper showed that, if the finishing slag was high in silica, the resulting steel was high in silicon and manganese. On the other hand, a finishing slag low in silica, about 51 per cent., resulted in a low silicon steel. The results indicated that the silicon transference from slag to metal was an effect, not of temperature, but of the silicious character of the slag. However, in order to further test the influence of temperature, the authors have conducted a series of experiments in a 25-ton furnace, and given the results before the recent American meeting of the Iron and Steel Institute. These later experiments confirm the earlier ones, for, by lowering the temperature of the bath, silicon in the steel, when in contact with a silicious slag, steadily rose. Thus, in one case, 8 cwts. of red bricks containing 78·9 per cent. silica, were added to the charge, thereby lowering the temperature and increasing the silica of the slag. Subsequent analysis showed a slow but steady rise in the silicon content of the steels. In continuing the examination of the influence of lime in the slag, on the silicon of the bath, a special charge was taken in which, after the slag had been thickening for 50 mins., 3½ cwts. of limestone were added. An addition which thinned the slag making it appear more basic than it really was in comparison with the fluidity of similar slags without the lime addition. With lime present the silica balance-point of the slag seems to be slightly altered, perhaps owing to lime not being an oxidising base, for with 53·5 per cent. silica in the slag, silicon in the steel is not lowered, but as shown in the following table, is slightly increasing.

Table III gives the details of a charge in which the lime addition was replaced by one of magnesia.

TABLE II.—LIME CHARGE.

Time.		Composition of Bath.			Additions.		Consistency of Slag.	Composition of Slag.						
Hr.	Min.	CC.	Si.	Mn.	Materials.	Cwts.		SiO_2	FeO	Fe_2O_3	Al_2O_3	MnO.	CaO.	MgO.
5	30	·54	·025	·049	—	—	Fairly thin	—	—	—	—	—	—	—
6	0	·53	·031	·055	—	—	Thickening	—	—	—	—	—	—	—
6	20	·44	·040	·064	—	—	Thickish	—	—	—	—	—	—	—
6	40	·36	·049	·074	—	—	Thick	55·45	18·49	1·61	2·02	20·77	2·09	0·89
6	41	—	—	—	lime	3½	—	—	—	—	—	—	—	—
6	50	·30	·051	·081	—	—	Thinning	—	—	—	—	—	—	—
7	0	·27	·052	·096	—	—	Thin	53·54	16·59	1·36	1·61	19·77	5·96	1·05

TABLE III.—MAGNESIA CHARGE.

Time.		Composition of Bath.			Additions.		Consistency of Slag.	Composition of Slag.	
Hr.	Min.	CC.	Si.	Mn.	Materials.	Cwts.		SiO_2.	Mg O.
3	15	·44	·026	·045	—	—	Thinnish.	—	—
3	30	·40	·029	·057	—	—	Thickening.	—	—
3	45	·29	·034	·063	—	—	Fairly Thick.	55·72	3·0
3	50	—	—	—	Magnesia	3	—	—	—
4	10	·19	·035	·067	—	—	Thinning.	—	—
4	28	·17	·037	·074	—	—	Thin.	54·03	4·0

TABLE IV.—PYROLUSITE, 22 TON CHARGE.

Time.		Composition of Bath.			Additions.		Consistency of Slag.	Composition of Slag.			
Hr.	Min.	CC.	Si.	Mn.	Materials.	Lbs.		Si. O_2.	Mn. O.	Ca. O.	Mg. O.
11	45	—	·20	—	—	—	Thin.	—	—	—	—
12	30	·74	·05	·104	—	—	Thickening.	—	—	—	—
1	0	·51	·051	·097	—	—	,,	56·74	16·45	2·96	Trace.
1	15	—	·063	—	—	—	,,	—	—	—	—
1	30	·42	·069	·09	—	—	Thicker.	—	—	—	—
1	45	·34	·079	·111	—	—	Very Thick.	57·62	17·48	—	—
1	48										
to		—	—	—	Mn. O_2.	440	—	—	—	—	—
2	0										
2	5	·29	·061	·115	—	—	Thinning.	56·7	18·14	—	—
2	10	—	—	—	Mn. O_2.	80	—	—	—	—	—
2	20	·25	·052	·109	—	—	Thinning.	55·8	17·4	—	—
2	35	·19	·066	·124	—	—	Thin.	57·2	18·4	—	—
2	50	—	·071	—	—	—	Thickening.	—	—	—	—
3	5	—	(·09)	—	—	—	,,	64·06	17·97	—	—

The last table, No. IV., gives the results obtained by allowing the slag to thicken as before and then thinning it by means of manganese di-oxide. Within the limits of the table no iron ore was added, and the charge on tapping behaved normally.

These analyses show the steady fall in carbon, after the addition of the manganese di-oxide. This addition thinned the slag and made it less silicious for a time, but by taking up silica from the acid materials of the furnace the new slag formed became viscous and highly silicious.

Tool Steel Forging and Tempering. A recent issue of *Machinery* contains an abstract of a paper by Mr. R. Henderson* on this subject, and from it we extract the following note as possessing some interest in these days of very special steels: "Carbon steel holds a finer edge than the air-hardening variety; it may be forged or worked into any shape required, and will always be used for tools required in exact work and for tools urged by impact. There should be about three grades: the first for taps, milling-cutters, reamers, and screw-cutting dies; the next for chisels, cold sets, hammers, etc.; and third one for flatters, swedges, dies for working hot metals, etc."

*Notes on Cementation.** The solubility of cementite in iron is ascertained indirectly through a study of the critical points of steels. It has, however, been attempted to obtain direct information by cementation tests, but comparatively few numerical results have been obtained. The author, in again investigating this question, has conducted many experiments with various carburising agents, the results being recorded in the following tables:—

Effect of Charcoal on Steel Wire Containing 0·04 % Carbon.			Iron Wire (0·04 % C) Heated in Illuminating Gas.			Soft Steel Wire (0·09 C) Heated in Cyanide of Potassium.		
Temperature °C.	Length of Treatment, Hours.	Carbon %.	Temperature °C.	Length of Treatment, Hours.	Carbon %.	Temperature °C.	Length of Treatment, Hours.	Carbon %.
770	7	0·11	925	5	0·15	510	14	0·63
925	2	0·54	935	6	3·50	600–700	32	3·77
950	3½	0·45	935	6	1·76	660	13	0·81
960	2½	1·42	935	8	1·09	660	7	1·32
1,000	2	0·79	975	8	0·67	745	7	2·60
1,000	2	0·47	1,000	8	1·64	825	2½	1·25
1,020	2	1·02	1,025	2	0·24	825	13	1·69
1,050	2	1·41	1,025	6	3·92	825	14	3·78
1,050	3	1·79	1,040	6	2·53	837	2½	1·08
1,070	2	1·45	1,050	6	2·53	875	2	1·10
1,080	2	0·47	1,075	5	2·37	875	7	1·21
1,125	3	3·12	1,075	8	1·04	900	13	3·47
1 175	wire melted					945	2	1·19
						965	4	1·12
						1,035	4	1·54
						1,070	2	2·00
						1,100	2	2·36

* Submitted to the 12th Annual Convention of the National Railroad Blacksmiths' Association.

* George Charpy. *The Iron and Steel Magazine*, Vol. VIII., No. 4.

Soft Steel Wire (0·09 % C) Heated in Cyanogen Gas.

Temperature °C.	Length of Treatment, Hours.	Carbon %.
850	½	0·55
880	2	1·79
990	2	4·32

In spite of the precautions taken the results are very irregular, and it was found that the slightest difference in the rate of heating in otherwise identical experiments resulted in notable differences on the amount of carbon absorbed. Microscopical examination of some of the examples showed in certain cases an excess of free cementite, in others an excess of graphite. It would, therefore, appear difficult to study the solubility of cementite in iron at high temperatures, owing to the decomposition of the cementite into ferrite and graphite. However, in further experiments the author succeeded in converting some iron wholly into carbide, a result only to be obtained at low temperatures owing to the necessity of avoiding the decomposition already noted. The results were obtained in the following manner :—Some fine filings of soft steel, 0·09 per cent. carbon, were heated to a temperature of about 650 degs. Cent. in molten cyanide of potassium. After various lengths of time a portion of the filings was tested for carbon with the following results :—

After 48 hours ... 4·50 per cent. carbon
„ 85 „ ... 6·72 „ „
„ 110 „ ... 6·72 „ „

The formula F_3C, representing iron carbide, calls for 6·67 per cent. carbon. After 86 hours, therefore, the iron was wholly converted into carbide, and longer treatment did not cause any further absorption of carbon.

Vanadium Steels. Vanadium, when present in comparatively small quantities, exercises a most powerful influence on the properties of steel, raising the elastic limit and breaking load with only a slight reduction of ductility. In view of the recognised importance of this element as a constituent of special steels, a paper by M. Guillet on vanadium steels in the October issue of the *Revue de Métallurgie* is not without interest. Following his usual plan, M. Guillet examines two series of steels, one comparatively low and the other fairly high in carbon. A glance at the later tables will, however, show that the contents of carbon in the second series are exceedingly variable. Microscopically, the first series, low in carbon, show normal pearlite when the content of vanadium is lower than 0·7 per cent. As this content is exceeded, white crystals appear, which increase in quantity as the content of vanadium rises. This special constituent, although not yet isolated, gives every indication of a carbide. Therefore, in summarising this section, the following groups may be noted : (1) Pearlitic steels, which yield a high elastic limit and breaking-load, and, in comparison with ordinary carbon steels, comparatively high elongations and reductions of area. They are not more fragile than ordinary carbon steels, but possess a greater hardness. (2) Intermediary steels, containing simultaneously pearlite and double carbide, the tensile strength of this group decreasing with an increasing content of vanadium. These steels are not more fragile than ordinary carbon steels, but are less hard than those of the first group. Quenching affects only the pearlite, and its intensity is therefore decreased as the content of vanadium increases. (3) Steels enclosing all the carbon in the state of the double carbide, and possessing feeble tenacities, but a fairly high range of ductility. They are fragile, but not hard, and quenching, no matter how effected, leads to no transformation, as judged by structure or mechanical properties. These three groups are shown in tabular form as follows :—

Group.	Structure	Content of Vanadium.	
		Steels containing 0·2 % C.	Steels containing 0·8 % C.
1	Pearlite	From 0 to 0·7 %	From 0 to 0·5 %
2	Pearlite and double carbide	From 0·7 to 3·0 %	From 0·5 to 7 %
3	Double Carbide	Exceeding 3 %	Exceeding 7 %

Mechanical Properties.—Results obtained from tensile, shock, and hardness tests are summarised in the two accompanying tables :—

First Series.

Content of		Elastic Limit.	Maximum Stress. Kilos. per sq. mm.	Elongation %	Reduction of Area %.	Frémont Drop Test. Kilogram-mètres.	Hardness. Brinell.
Carbon.	Vanadium.						
0·114	0·29	30·2	43·8	24·0	62·5	30	140
0·131	0·60	41·1	52·9	20·0	69·3	20	159
0·141	0·75	43·4	57·7	15·5	58·2	19	217
0·112	1·04	45·4	61·1	15·0	70·8	20	217
0·130	1·54	44·8	56·4	19·0	72·5	30	159
0·200	2·12	39·4	50·4	15·0	67·8	25	159
0·187	2·98	26·8	47·1	26·0	73·8	22	99
0·387	5·37	25·5	46·5	17·0	61·0	6	143
0·130	7·34	24·8	43·8	30·0	62·7	2	109
0·129	10·27	25·3	46·5	21·0	53·1	4	118

SECOND SERIES.

Content of		Elastic Limit. Kilos. per sq. mm.	Maximum Stress. Kilos. per sq. mm.	Elongation %	Reduction of Area %	Frémont Drop Test. Kilogram-mètres.	Hardness. Brinell.
Carbon.	Vanadium.						
0·216	0·25	43·8	88·5	8	20·3	3	286
0·725	0·60	47·4	92·3	8	22·4	4	302
0·886	0·80	56·2	96·2	4	19·3	4	532
0·674	1·15	58·3	87·5	8	26·2	3	286
0·618	1·58	64·1	94·9	9	31·3	3	262
0·950	2·89	48·1	91·4	9	33·9	2	286
0·666	3·06	58·2	85·2	16	28·5	3	262
1·084	4·99	55·3	98·9	14	25·3	5	255
0·737	7·85	28·9	51·7	20	34·3	3	143
0·258	10·25	31·6	62·5	12	37·5	0	179

Trial of a Method of Classifying Steel.—To distinguish one steel from another without the aid of chemical analysis is a matter of some difficulty. As is well known tool smiths can, by instinct or intuition, pick out from an assortment of various steels the particular one required. In other cases some index of the steel may be gained from the note emitted when the bar is struck: needless to add intuitive or musical methods are by no means infallible. However, as opening a new field in this direction, M. Demozay gives, in the October issue of the *Revue de Métallurgie*, a careful analysis of the nature and kind of sparks emitted by various steels when subjected to an abrading action. Various steels have been tested by grinding on an emery wheel, the characteristics of the resulting sparks and sheaves being carefully noted. Thus in the case of steels containing from 0·1 to 0·3 per cent. carbon the spark is only truly luminous in the part which flashes. As the content of carbon increases the number of secondary flashes increases, and the principal flash begins to assume the form of a flower. This flower increases in brilliancy with the content of carbon in the steel tested, and often from these flowers stalks are detached which themselves give birth to new flowers. By careful and direct comparison the distinction between forged and unforged may be detected, but annealing has apparently no influence on the character of the sparks or form of the sheaf. In quenched steels the form of the spark remains the same, but the sheaf increases in fulness, containing four or five times the number of sparks. An interesting experiment is found in grinding a superficially cemented steel; for here, as one travels through the hard outer surface to the softer interior, the aspect of the sheaf changes according to the content of carbon. In a similar manner M. Demozay has examined the sparks emitted by various special steels, including chromium, nickel, and manganese, each steel producing characteristics peculiar to itself. The subject is an interesting one, and will admit of much further work before really definite conclusions are reached. As a rough guide in selecting a required steel from an assortment it may prove of some value: in any case the grinding must always be done under strictly comparative conditions, and in order to more clearly study the sparks, should be carried out in a fairly dark room.

Foundry Practice.

Use of Manganese in Cupola or Ladle.—The use of manganese as a desulphuriser is recognised in most foundries, but opinion is divided as to whether it should be added in the form of crushed ferro-manganese to the ladle or as manganiferous pig-iron to the cupola charge. Mr. N. W. Shed,* in discussing these features, details some interesting experiments, showing that when manganese is added to the ladle the sulphide formed rises to the surface. A similar action also occurs in the castings, and on subsequent analysis the top surfaces are found to be higher in sulphur and manganese than the bottom ones. A remarkable confirmation was found in the case of a 2,000 lb. roll, the top of which contained 1·07 per cent. sulphur and 1·02 per cent. manganese. Analyses of drillings taken from various parts of this casting are shown in the accompanying illustration, where the noteworthy increase of sulphur and manganese on reaching the top of the casting will be noted.

Section of Roll showing floating of Sulphur and Manganese.

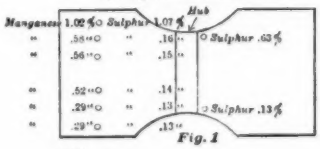


Fig. 1

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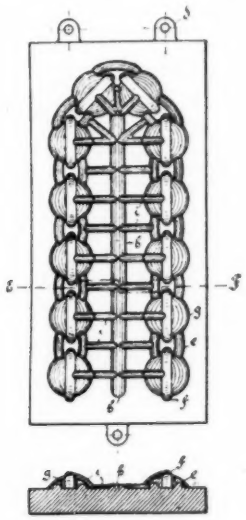
Other confirmatory instances are quoted, all tending to show that ferro-manganese added to the ladle results in the castings showing a pronounced segregation of sulphur and manganese towards the top of the castings. On the other hand manganese added in the form of manganiferous pig-iron to the cupola charge results in no such difference in the casting, the top and bottom yielding the same amount of sulphur and manganese.

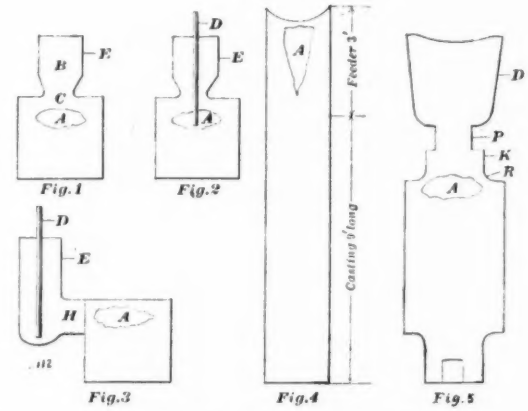
* *The Iron Trade Review.* Vol. xxxvii. No. 41.

A Method of Moulding Chains. Various efforts have been made to cast chains in sand moulds, a feature of one method lying in the use of a resin pattern. In moulding from such a pattern the links must be carefully separated, and the sand carefully rammed between them. Each link must be provided with a runner and riser, which, on heating the moulds in an inverted position, serve as channels for the escape of the resin. Obviously such a method possesses many disadvantages, amongst which will be noted the destruction of the pattern and the heavy trimming involved in cutting off a gate and riser from each link of the chain. Disadvantages of this type are eliminated in a new method of chain moulding described by Mr. R. Schütze in the October issue of *Giesserei Zeitung*. Briefly the method is as follows:—A pattern plate, as in the illustration, is employed, the interior of every other link being formed by a core, shown as core prints on the figure. A central runner and gates to each link also form part of the pattern plate. The improvements effected in steel metallurgy readily permit of very fluid steel being obtained, hence the author views this method of chain casting as one likely to prove of value.



METHOD OF MOULDING CHAINS.

Shrinkage Troubles and Methods of Feeding. Mr. T. W. West, in a paper read before the New England Foundrymen's Association,* described unsoundness in castings as due to one of three causes: "a blow hole," "dirt hole," or "shrinkage." The difficulty in obtaining many bulky castings sound lies in the solidification of the exterior before the interior, and the difficulty of conveying to the part solidifying last, the hot metal to replenish its shrinkage. As an example, the last portion to solidify in the case of a cube, Fig. 1, would lie in the vicinity of *A*. If an open communication can be maintained between *A* and the feeder *B* until *A* has solidified, a sound casting will result. Such a communication may be maintained by the use of a feeding-rod, as shown in Fig. 2, the agitation of the rod keeping a liquid opening to supply shrinkage in the casting. The cost of removing large feeding-heads leads, in certain cases, to the use of smaller heads than are desirable. Were it possible in all cases to employ a head as large as the body to be fed, Fig. 4, there would then be little difficulty in obtaining sound castings. Exterior-rod feeding is described as that in which the feeding-head is placed at the side of the casting and a channel cut between the two as shown in Fig. 3. The chief difference between the methods of Figs. 2 and 3 lies in the latter not permitting the feeding-rod to penetrate the casting—undoubtedly the former method is the better one. Statical pressure feeding includes a class of castings involving the principle shown in Fig. 4. In this case, whilst relying on self-feeding, it is advisable to feed down with a rod for a few moments after each fresh addition of metal to the feeding-head. The surface of this head should also be covered with charcoal dust in order to minimise the escape of heat. Wabblers on rolls effectively close connection between the body *K* and the head *D* of Fig. 5, so much so that some founders make the part *P* of the same size as *K*, turning it down to size after cutting off the head. When this plan is not followed the feeding rod



SHRINKAGE TROUBLES AND METHODS OF FEEDING.

* *The Iron Trade Review*. Vol. xxxvii. No. 42.

must be diligently used, otherwise shrink holes and sponginess will be found round the neck at R. Chill feeding consists in forming, by means of a chill, any section or part of a mould likely to give trouble from shrinkage. A chill applied to a heavy part hastens solidification, hence by suitable chilling the thicker portions of a casting may be made to cool at a rate more nearly equal to that of the lighter ones; equal cooling, of course, minimising shrinkage evils.

*Cost of Melting Brass in Oil Furnaces.** The writer gives the following figures for a month's run, during which 7,800 lbs. of brass were melted. When using crucibles in coke furnaces $303·4, and when using an oil melting furnace of the rotary type $54·6. The oil furnace, therefore, effected an economy of $248·8.

General.

The Manufacture of Zinc Oxide. The growth of this industry is attributed to the substitution of zinc white for white lead as a pigment. In Europe a fair amount of the zinc oxide produced is obtained from metallic zinc, whilst in America the greater portion is obtained direct from the ores of zinc. The method of manufacture employed at the Ozark Zinc Oxide Works, Joplin, is described by Mr. L. M. Davies in a late issue of the *Mining World*, from which we gather that the process is a modification of that devised by Witherill in 1851. The screened ore is assayed in order to determine the required flux—details of which are not given. The fuel charge generally consists of 1,000 lbs. of coal to a quantity of ore equivalent to 300 lbs. metallic zinc. The ore mixed with powdered coal and fluxes is charged on to the hearth of a furnace in which either a reducing or oxidising atmosphere may be maintained. The working temperature reaches about 3,000 degs. Fahr. The first stage is in the production of metallic zinc, which in turn is volatilised, and on cooling below 2,192 degs. Fahr. unites with the oxygen of the carbonic acid gas forming zinc oxide and carbon mon-oxide. This oxide in the form of a fume is passed through clarifying towers for the removal of suspended foreign matter, thence through a cooling pipe and collected in a series of sheet-iron pipes. The open top of these pipes is closed by muslin, permitting the escape of gases but retaining the oxide.

A West African Smelting House. Mr. C. V. Bellamy* describes in a most interesting fashion the method pursued by the natives of Ola-igbi for the production of steel. Generally the process is a direct one, and the product a "natural steel." The method is, in all probability, akin to that of the very earliest iron or steel workers. The ore is quarried at a depth of 6 or 8 ft., calcined by roasting on a fire of green timber and then pulverised in a wooden mortar. After screening the ore is washed, and is then ready for smelting. This process is conducted in a primitive furnace, in which the charcoal fuel reduces the ore, and the fusible oxides added as flux partially decarburise the metal which collects in a sponge at the bottom of the furnace. On removal the sponges are broken and sold to native smiths, who, in working the material up, effect a further decarburisation, the blast of the smith's hearth supplying the necessary oxygen.

Comparison of Methods for the Determination of Carbon and Phosphorus in Steel. A committee consisting of Baron Jüptner von Jonstorff, Messrs. Blair, Dillner and Stead have presented a report to the recent Iron and Steel Institute meeting, embodying their individual methods of determining carbon and phosphorus. A series of uniform steels were obtained, and each analyst estimated these elements in the sample supplied to him. The following are the average results obtained by the various workers:—

AVERAGE OF METHODS APPROVED BY EACH ANALYST.

		H. 971.	M. 76.	H. 739.	L. 422.
		Per cent.	Per cent.	Per cent.	Per cent.
Dillner	Carbon Determinations.	1·46	1·02	0·45	0·10
		1·45	1·01	0·44	0·10
Jüptner		*a* 1·57	1·105	0·459	0·141
		b 1·52	1·071	0·439	0·0936
		c 1·439	1·046	0·424	0·140
		d 1·450	1·068	0·459	0·142
Blair		1·415	1·040	0·434	0·098
		1·412	1·038	0·432	0·097
Stead		1·44	1·035	0·420	0·10
		1·40	1·020	0·420	0·096
Dillner	Phosphorus determinations.	0·0225	0·0225	0·0230	0·030
Jüptner		0·0305	0·0320	0·0275	0·027
Blair		0·0190	0·0180	0·0220	0·026
Stead		0·0230	0·0245	0·0245	0·0295

* J. F. Webb. "The Foundry." Vol. XXV. No. 2.

* American Meeting, Iron and Steel Institute.

ABSTRACTS.

Coast Erosion.

By A. E. CAREY, M.Inst.C.E.

Erosion on the Holderness Coast of Yorkshire.

By E. R. MATTHEWS.

Proceedings of the Institution of Civil Engineers, Nov. 8, 1904.

THE first paper points out that, in the struggle between sea and land, the frontiers of England are being continuously pushed back, but land wastage from this cause is a matter which is left almost entirely to those immediately concerned. If the bank of a river bursts, similar apathy does not prevail. Scot is levied, and the damage is made good; but an irruption of the sea is, generally speaking, looked upon as a thing unavoidable and beyond control. The evils of the present lack of system are due to sporadic activity, an excess of authorities, and an absence of general control. The author describes the evolution of a seaside village, subject to intermittent inundation, into a watering-place, in front of which it is sought to trap the whole of the travelling shingle, with disastrous results to leeward, and frequently to the town itself when its borders are extended. He cites as an analogous situation the plight of riparian landowners, should one owner farther up-stream have the right to dam or divert a river at will.

The author suggests that a short Act clearly defining the law is the first requirement, and urges that a new body should be created, with the special function of dealing with the foreshores of England and Wales as a whole, unfettered by the restrictions now existing. He then details the functions and powers with which he thinks this Coast Commission should be invested, and points out that under the title of "mundbriech" the Cinque Ports formerly enjoyed similar rights under Royal Charters. He also suggests the division of the necessary expenditure between the Treasury, the local authorities and the landowners, and the rights which should be conferred upon the commission in the possible acquisition of foreshore lands, as well as their management.

He suggests that the Commission should appoint six district engineers or coast wardens for the following districts:—Berwick-on-Tweed to the north of the Humber; the south of the Humber to the Essex shore of the Thames; the Kent shore of the Thames to Poole Harbour (including the Isle of Wight); thence to the Severn; the Welsh coast; thence to the Scotch border.

He points out that one advantage of a single authority to deal with the entire coast line would be its capacity to make use of surplus shingle or other material to tune up a threatened coast line to safety. By this means, he thinks, safety could often be secured at a comparatively insignificant cost. The problem, if studied as a whole, would prove far less formidable than as now, when it has to be dealt with piecemeal. He shows how impossible it is in many cases for local governing bodies to do anything effective, owing to the magnitude of the problem, the conflict of interests, and the want of adequate authority.

The paper is not intended to set out the principles and practice of defence measures from an engineering standpoint, but to deal with the matter from the administrative side. It then briefly describes the actual coastal conditions along the six districts enumerated, the principal localities of active coast erosion being from Bridlington to Spurn Point, and along the East Anglian coast.

In connection with the accretion of shingle at Dungeness, the author points out that apparently the rate of accretion is diminishing. He attributes the growth of this accretion primarily to deep-sea currents rather than to littoral movement, as the addition to the volume of Dungeness appears to be about 200,000 tons per annum, whereas the quantity of shingle in circulation west of Hastings is only 60,000 to 70,000 tons per annum, and merely a small portion of this passes to the eastward.

By means of a skeleton map, the geological stratification along the coast line of England and Wales is shown, also the principal localities of erosion. The author points out that if Professor Darwin's view, on astronomical grounds, that the tides had within geological times a vertical range twice as great as at present, be correct, it helps to explain existing coastal phenomena. He holds as not proven the theory that within the historic period any general or local subsidence of the sea bottom has taken place. From the position of Roman coins discovered at Rossall it is inferred that there the level of sea and land has remained constant since the period of the Roman occupation.

The author briefly enumerates the salient geological features of the coast line, and points out their connection with the relative rates of erosion. He then deals with the artificial causes of erosion, and quotes the report of the British

Association for 1895 that this is largely due to the abstraction of materials from the foreshore and the construction of badly designed preservation works. As a guide to the solution of the general problem, a statement is given of the practice in other countries with regard to the rights and obligations of the State in foreshore questions.

In conclusion, the author details the efforts in 1903 of the East Anglian municipal authorities to deal by united action with the question on that coast. These have resulted in absolute deadlock; owing to the absence of expert opinion, neither the Board of Trade nor the local committee being prepared to initiate measures of defence. Meantime, the ravages of the sea are unprecedentedly severe.

The second paper deals with the effects of erosion on the most strongly attacked portion of the English seaboard, namely, the coast between Bridlington and Spurn Head, and gives an account of the remedial measures which have been adopted at Bridlington and at other towns, and of their effects upon the foreshore. Almost the whole of this coast line is being eroded at an average rate of about three yards per annum; and on the assumption of continuous erosion at that rate it is calculated that 115 sq. mls. of land have disappeared between Flamborough Head and Kilnsea (a distance of 40 mls.) since B.C. 55; and in that time the sea has encroached upon the land 3¼ mls. The bed of the sea is also being eroded. The eroded material is carried in a southerly direction, and much of it is deposited at Spurn Point; but the author is of opinion that a large portion finds its way into the estuary of the Humber, and that some of it even crosses that estuary and is deposited on the Lincolnshire coast.

The paper describes the various works that have been carried out from time to time, with the object of protecting the coast, at Bridlington, Hornsea, Withernsea, and Spurn Point. During the past 35 years the corporation have spent about £73,000 in protecting the north foreshore of Bridlington, the south foreshore being maintained by private landowners. The sea-defence works at Bridlington consist of sea-walls built along the shore and groynes projected across the foreshore either at right angles to the coast line or approximately so. Some of the walls are constructed of timber, with a filling of block chalk; others are of concrete and masonry. Their design is described and illustrated in detail.

The earlier heavy timber groynes, consisting of timber frames filled with chalk, proved fairly effective in breaking the force of the waves, but were too high to have proper effect in causing accretion on the foreshore. The later construction of four long low timber groynes, however, had the result of causing within three years the accumulation of 500,000 tons of sand on the foreshore, raising the beach to an average height of about 4 ft. over an area of 26,000 sq. yds.; and a further nine groynes of the same kind have had a similar effect. The protective works at Hornsea consist of groynes and timber breast-work, carried out by private enterprise. At Withernsea, six groynes and a sea-wall along the whole frontage have been of great service in maintaining the foreshore. The timber groynes erected by the Board of Trade between Kilnsea and Spurn Point and at the Point have been very successful, and have resulted in the accumulation of an immense quantity of shingle and sand.

The author then proceeds to consider what measures are needed for the protection of the whole of the Holderness coast, and suggests that a continuous permanent sea-wall along the whole length and also ten long groynes per mile would be required. He is of opinion that the latest type of sea-wall and groyne constructed by him at Bridlington would be suitable, and he finds that the cost of the suggested works on this basis would be about £1,247,000, of which £110,000 would be for groynes. On the other hand, the value of the land swallowed up by the sea in the 33 years' life of the groynes would be about £34,000, or only about one-third of the cost of the groynes alone. Consequently it is impossible that the landowners should bear the cost of protection, and the question naturally arises, "Who should bear it?" The author strongly urges that this is a matter of national importance, and that just as the Board of Trade protects Spurn Point and four miles of coast line adjoining it, so the whole of the coast line between Kilnsea and Bridlington should be protected by them against the inroads of the sea.

The paper concludes with some particulars of what is being done by government in Holland and Belgium to protect the foreshores of those countries, and of the amount of money devoted by the Belgian Government to such work; also with statistics of the loss of land throughout Great Britain in the years 1867-1900.

Chlorine in Metallurgy.

By James Swinburne, M.Inst.C.E., M.I.E.E.

Proceedings International Elect. Congress, St. Louis.

The essence of metallurgy, as practised for thousand of years, is the reduction of the oxide of the coveted metals with carbon, as such or as monoxide. Some metals, notably iron, exist in nature ready as oxide, but most of the others are found as sulphides. The sulphides are, therefore, roasted to convert them into oxides, and the oxides are reduced with carbon. Modern metallurgy broadly consists of the reduction of oxides to the metallic state.

The process I have the honour of bringing before you depends on the action of chlorine. Chlorine has been used in metallurgy before for attacking metallic gold, and salt has been employed for "chloridising" roasting. The present process is, however, a new departure, of quite a different kind, and really a new form of metallurgy calculated to displace the oxidation and reduction processes now in use to a great extent. How far the replacement will take place depends eventually on economy only.

The principle of the process is treating sulphide ores, without previous roasting with chlorine, so as to form chlorides of the metals, the sulphur being liberated as such. The chlorides are then electrolysed, yielding metals and recovering the chlorine. The chlorine thus goes round and round; and the process in its simplest form is analogous to separating the sulphur from the metals electrically, and changing the ore, at the mere expense of electrical energy, into its component metals and sulphur. This can in fact be actually done. In one of my first patents there is a description of electrolysing a bath of, for instance, zinc chloride and zinc sulphide, with carbon anodes and fused zinc cathode. This gives off zinc at the cathode, and pure sulphur, not chlorine, at the anode. This simple method is not applicable to many ores on account of gangue, iron, and other metals. It is mentioned to give a clear idea of the essence of the process.

In practice there are further modifications. The process naturally gives the best commercial return on ores that are refractory to other treatment; and complex ores yield mixtures of chlorides and gangue which could not be electrolysed straight off without intermediate treatment. The intermediate treatment is always simple chemically, and consists in removing the gangue, and substituting zinc for the other metals one after the other till there is nothing but chloride of zinc left. This chloride of zinc is then electrolysed and the zinc and chlorine recovered. If there was no zinc in the ore, all the zinc obtained is used up again; but if there was zinc in the ore it is sold as zinc.

The action of chlorine on sulphides is generally very vigorous, and enough heat is generated to keep the mass hot. The transformer is something like a small cupola. It is an iron vessel lined with firebrick, and it contains mixed chlorides fused carrying the gangue and ore. The ore is run in at the top continuously, and chlorine is pumped in at the bottom; sulphur coming off and passing over into a condensing chamber. There is no difficulty about pumping chlorine. Iron cylinders, pistons and valves are employed, and, as is well known, though not fully realised, dry chlorine, such as that from the electrolysis of fused chlorides, is a very harmless gas.

The transformer is tapped at intervals, and the mixed chloride and gangue run into water. Broken Hill slimes, a waste product daily becoming more mountainous, have been chosen to work upon. They contain zinc, lead, iron, silver, manganese, sulphur, and gangue. The gangue and lead chloride come out together, and the lead chloride is separated, the silver extracted, and the lead chloride electrolysed. The soluble chlorides are treated with chlorine, to get ferrous into ferric chloride, and the iron precipitated with zinc oxide or calamine. The manganese is got out separately or with the iron in a similar way. The zinc chloride is then boiled down and electrolysed. The electrolysis vat is simply an iron case lined with firebrick, and is kept hot by the excess of the electric over the chemical energy.

The history of the process is simple. The first patents were in 1897, and the process was tried in the laboratory, and everything worked well. It was then tried on a pound scale and worked. A plant was taken in Milton, and large-scale experiments on electrolysis and handling of chlorine were carried out. A 3,000-amp. electrolytic vat was run continuously for three months. Facilities were wanting there. Mr. A. J. Smith, the general manager of the Castner-Kellner Co., saw a chance of a future in the process, and the company made arrangements for us to put down an experimental plant next door to its works. This was done, and the transforming was proved on a large scale.

We have repeatedly learned from the technical journals that the chlorine reaction does not take place, and that fused zinc chloride cannot be electrolysed. In fact, people have proved it with test tubes. The Castner-Kellner Co., however, was able to investigate the working of the process, and to inspect the transformer consuming at the rate of 30 tons a week. It was well enough satisfied with the results to arrange to take the works over, acquiring a licence to make chloride of zinc. It thus uses the whole process except the electrolysis, as they have a supply of chlorine from the soda works. It will run a 10,000-amp. vat for demonstration, but otherwise will sell every metal but zinc, the zinc being sold as chloride. The only difference in the process is that zinc chloride must be much more highly refined for the market than for electrolysis, as a trace of manganese, for example, would spoil the colour, but would do no harm in electrolysis. The chlorine is also damp, and has to be dried before being pumped.

A good deal of work has been done recently on the treatment of ores with little metal content, such as copper ores running under 3 per cent., and copper nickel and cobalt ores. These modifications have only been tried on the small scale, and so it is too soon to speak yet, but apparently low grade copper, and nickel, cobalt and, of course, their mixtures, and copper zinc ores of low content will prove amenable.

The Blake-Morscher Electro-Static Separator.

By Ernest A. Weinberg.

Proceedings of the Inst. Mining & Metallurgy, Nov. 17th, 1904.

The principle of separating conductors and nonconductors, by means of static electricity, has found practical application for the separation of some minerals from each other, also for the separation of minerals from their gangue. Any mixture consisting of conductors and nonconductors passing, say, over a feeding board or lip, which is connected with some source of electricity, it is charged with a potential, which according to the pole connection may be either "plus" or "minus." If this mixture is now dropped from the feedboard upon a repelling plane, which

is charged with an opposite potential to that of the mixture, it will endeavour to take up the same potential.

The good conductors in the mixtures will do this instantaneously whereby they are repelled from the conducting plane, and in a properly arranged machine caught in a special receptacle. The non-conductors, however, will only give up their original charge very slowly and adhere to the plane, as they are attracted to it owing to its opposite electricity, but before they have time to take on the same potential they can be made to fall into a special receptacle. If the mixture is not from the beginning charged with a potential opposite to that of the repelling plane, the action is the same, only with the difference that the mixture does not need first to give up one charge before taking up another.

The difference in time between the taking up of the new potential by the conductors and non-conductors respectively in a "neutral" state, will be shorter than in the case in which the material reaches the repelling plane charged with an opposite potential.

In the practical application of the principle, a falling stream of crushed material is brought into contact with a suitable repelling arrangement, which may consist either of a revolving drum, or a stationary inclined plane, both made of insulated metallic conductors, which are charged with electricity, either by induction or by being directly connected with a source of electricity.

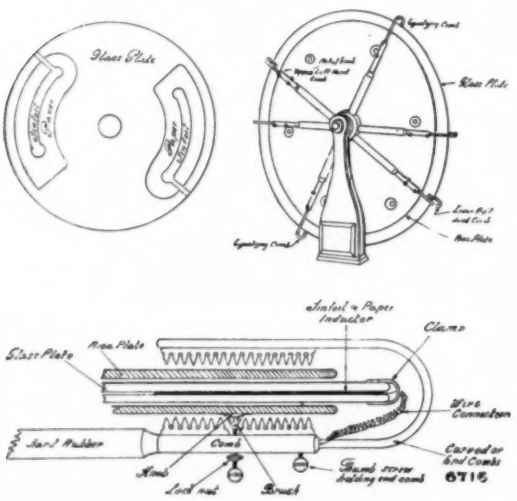
The separator is constructed almost entirely of pine timber, and is 10 ft. 6 in. long, 8 ft. high, and 3 ft. 4 in. wide. The ore is fed by means of a small cup elevator into a box which is provided with the screw conveyor, acting as distributor for two feed-hoppers. From here the ore drops on feed-boards, and finally reaches the four revolving repelling poles which are connected with a source of electricity in such a way that the upper two are negative, and the lower two positive. The poles may consist of iron, copper, or brass tubing 9 ft. 6 ins. long, and varying in diameter from 1½ ins. to 3 ins. The speed at which the poles revolve is adjusted to suit any individual ore under treatment.

Underneath the poles is a system of pockets allowing the collecting of three separate products, viz.: (1) good conductors which are repelled furthest; (2) lesser conductors (here middle product) which are slightly repelled; (3) non-conductors or insulators, which are not repelled at all.

The good conductors are discharged upon another feed-board and fall from here on a finishing pole which separates it into two products, the first being a finished product consisting of good conductors which is discharged from the separator by means of a screw conveyor. The second is a middle product consisting of lesser conductors.

The non-conductors of the first separation are discharged and separated in a similar way into two products, the first being a finished product consisting of non-conductors or insulators, and is discharged by a screw-conveyor, the other is a middle product consisting of lesser conductors. All middle products coming either from the upper or lower poles are conveyed back by a screw-conveyor to the boot of the small cup-elevator which delivers the material again into the box.

In the experiments carried out by the author a Wagner mica plate static machine has been used, and it is as well to add that in Colorado and Wisconsin, where at present larger installations are in operation, the same type of influence machine has been adopted.



WAGNER MICA PLATE STATIC MACHINE.

As the Wagner static machine is very little known on this side of the Atlantic, a short description may not be out of place.

Like all static machines, electricity is developed by an influence upon the molecular structures of the air. In the Wagner machine the action takes place between strips of tinfoil and paper (the inductors) sealed between two stationary glass plates (32 ins. in diameter) and the air in contact with the outer surfaces of two revolving mica plates (28 ins. in diameter and $\frac{3}{16}$ths in. thick). The mica plates are built up of many layers of thin mica plates and shellac which finally have been submitted to hydraulic pressure.

In order to set up an action on the air, the strips of tinfoil and paper are charged initially from the frictional charge developed by six small wire brushes which are held in the collecting combs in such a

manner as to strike six small metal knobs cemented by means of shellac upon the surface of the mica plate.

The frictional charge generated by the brushes is picked up by the lower right-hand comb and the upper left-hand comb, and is communicated to the inductors through a wire, which is held in contact with the strips of tinfoil (leading out from the conductors between the glass plates) by a clamp. The arms holding the collecting combs are made of hard rubber, with the exception of the upper right-hand arm and the lower left-hand arm, which are holding the equalising combs, and are made of black enamelled brass.

The mica plate and the metal flange holding the hard rubber arms and collecting combs, are mounted on a short piece of stout shafting, the bearings are all ball-bearings, and the mandrils are packed with sufficient hard oil to last several months. The glass plates do not touch the shaft, but are held between the mica plates by one upper and two lower hard rubber supports, which are slotted to take in the glass plates.

In order to make wire connections with the separator, two connecting-rods are screwed into the central collecting combs, and extend about 12 ins. outside through a hard rubber casing.

The speed of the static machine may vary between 500 and 1,000 revolutions per min. according to requirements, the voltage is a very high one, varying according to speed from 200,000 to 300,000 volts, while the volume of the static current amounts to only a few milliamperes.

Up till now the practical application of the electro-static separator is restricted to the separation of the blende from pyrites, but it is particularly well adapted to the separation of diamagnetic blende, which owing to the absence of chemically combined iron or manganese does not lend itself readily to magnetic separation.

Although no practical installation is at present at work on any other ore or mineral mixture, the author, on the basis of a series of working tests, has every reason to believe that it may be used to great advantage in the dressing of crude graphite, and likewise for the concentration of certain hematites.

The following table contains only a list of conductors and non-conductors which have come under notice in the course of testing ores and mill products :—

Conductors.—Pyrites, chalcopyrite, marcasite, pyrrhotite, hematite, magnetite, siderite, cassiterite, wolframite, rhodonite, garnet, galena, graphite.

Non-Conductors.—Quartz, dolamite, gypsum, calcite, barite, apatite, sphalerite, smithsonite.

The paper concludes with tables of practical working results obtained, of which the two following will serve as examples :—

Colorado. — Vanner concentrates from the Bonanza Mine, Gilpin County, containing approximately Pb 5·5 per cent., Zn 29 per cent., Fe 22·8 per cent., SiO_2 5·2 per cent., Au 0·24 oz., Ag 6·56 oz. per ton, when treated on the Blake Separator, gave the following products :—(*a*) Pyrites product 36 per cent. of original weight with approximately Pb 10 per cent., Zn 6·2 per cent., Fe 40 per cent., SiO_2 2 per cent., Au 0·37 oz., Ag 8·13 oz. per ton. (*b*) Blende product 63 per cent. of original weight, containing Pb 2·2 per cent., Zn 44 per cent., Fe 10·9 per cent., SiO_2 6·8 pet cent., Au 0·16 oz., Ag 5·24 oz. per ton.

Germany (Stolberg).—Samples of middlings consisting of pyritic blende (partly diamagnetic) about 30 mesh and containing 36·9 per cent. Zn gave over the Blake machine (*a*) Pyrites product, 39 per cent. of original weight with 8·2 per cent. Zn, and (*b*) Blende product, 61 per cent. of original weight with 54·3 per cent. Zn, thus showing a saving of 90·2 per cent. of the Zn contained in the original material.

Impact Tests on the Wrought-Steel of Commerce.

By Mr. A. E. SEATON and Mr. A. JUDE.

Proceedings of the Institute of Mechanical Engineers, Nov. 1904.

CONSIDERABLE movement has been made of late towards the establishment of a shock test for steel, conducted on a smaller scale than is the custom with axles, for instance, where the full-sized article is tested. The authors are strongly of the opinion that progress in this direction is taking place still too slowly, and it is therefore the aggregate object of their paper to help forward a further appreciation of this valuable test. The tensile tests described by them were made in a Buckton testing-machine, while the shock tests were carried out in an apparatus designed by the authors to require, as a rule, more than one blow to produce fracture. Such apparatus consists essentially of a weight of 6 lbs., arranged to drop freely through 24 ins. on to the test-bar, which rests on fixed supports 3 ins. apart, The test-bar is 4 ins. long, so that there is an ½-in. overlap at each end. After each blow the test-piece is reversed.

A large majority of engineers rest content with tension tests alone, no matter to what use they are putting the steel; some, perhaps, because it is rather an expensive test, taking into consideration cost of plant, etc. It is consequently sometimes stated that an ordinary mild steel is not good for certain purposes, but that a particular "special" steel is perfectly safe, etc., *because the elastic limit and tensile strength are somewhat better.*

A similar assertion is made in the Sixth Report to the Alloys Committee* in reference to heat-treated steel for guns. How much is this tensile strength and elastic limit thereby raised? The answer is—anything from about 5 to 30 per cent.

The increased percentage must be a mere trifle for such articles as are subjected to stresses or

* Proceedings Inst. Mechanical Engineers, 1904. Part I., p. 78.

shocks of an unknown effective magnitude, and it seems absurd to say that the difference between danger and security in a gun is ever met by 30 per cent. increase in the quality of the steel.

But, nevertheless, it is certain that such treated steel is suitable for its purpose, and it is evident therefore that something far more important has been contributed to the original qualities of the material than the mere improvement in tensile properties to account for it. It is because the shock strength is improved several hundred per cent., as against the insignificant increase of, say, 30 per cent. at the most in the tensile strength and elastic limit.

The general uses of steel may be divided into three main groups: (*a*) Structural work subject to steady loads only, such as boilers, buildings, tanks, etc.; (*b*) structural work subject to recurrent loads of one kind at intervals, in addition to the load due to its own weight, such as bridges, etc.; (*c*) structures subject to rapidly repeated loads of one kind, all more or less suddenly, applied, as with bolts and studs, rails, etc.; (*d*) structures subject to alternating loads, such as in the fixed and moving parts of machinery in general, and in many parts of a ship.

For the first two there is no doubt that the tension test is a good and sufficient one, as the predominant stress is certainly pure static tension, but it will be insufficient for the very heterogeneous groups (*c* and *d*). Attention is drawn by the authors to an analysis of stresses in the steel parts of an up-to-date steam-engine of moderate size, which shows that 87·6 per cent of the whole engine is subject to more or less shock, while pure tension forms an insignificant percentage of the total stress. There are important parts, such as the piston-rods and connecting-rods, that under ideal conditions of working are subject mainly to direct alternating stresses. When the piston-rod gives way, in the majority of cases, it breaks through a section where the effect of repeated blows can accumulate. There is undoubtedly, in addition to the suddenly applied steam loads, a series of true though comparatively minute blows (with proper adjustment) arising from the necessary slackness in all the bearings.

The question may be asked: "Why do not this rod and similar pieces of machinery break in the same place by the accumulated effect of stress reversals or variations, just as well as with a series of blows? It may be possible that they do so in some cases, but the authors put forward some considerations which incline them to the opinion that this is not the case as a general rule. One of these points is that it is well known that the resistance to alternating stress (rotation method) *increases* with the carbon content and elastic limit of the steel, but the resistance to shock *decreases* with an increase in those factors for "normal steel."

It has been found in a large number of instances that where fracture has occurred after a few hours' work when using normal medium grade steel (0·25 to 0·3 Carb.), this occurrence has been either greatly delayed or indefinitely postponed by the substitution of low-carbon steel, especially when in its best toughened (fine-grained) condition. Therefore, apart from the question whether even 30 blows given by this particular machine is a good and sufficient insurance against fracture, the point is that it is not satisfactory to subject all steel to one particular test just because that test may be a suitable one for large quantities of it for one particular purpose. Let there be these particular tests for bridge steel and boiler steel by all means, but steel that will be used for the miscellaneous forgings of machinery in general should be tried by its own crucial tests. Car-axles, cranks, and similar articles, perhaps, should be subjected to an alternating stress by the rotation method instead of by the shock test, as in their case also the tension test is almost useless as a gauge of the suitability of the material.

It must not be concluded that the factors of elastic limit, etc., are despised, but since the forces that cause breakage are in practice far below the elastic limit in magnitude, and moreover as the factor of safety is quite arbitrary and the same in no two pieces of machinery, it seems to the authors that the cart is put before the horse to a great extent. In fact, under the usual conditions of design one knows enough about the elastic limit which can only vary in a given grade of steel between comparatively small and insignificant limits, whereas the shock strength can vary almost between infinite limits.

From the very many bars that have been tested by them they have found the number of blows to produce fracture is a fair gauge of the toughness or anti-brittleness. But there is no relation whatever between this result and the tensile results, except that if the impact result is good the elongation is sure to be good too; but, on the other hand, the authors show that a steel with high tensile strength and good elongation may be useless to resist shock.

Although there is no relation between the tensile-stress test and the alternating-stress test, or between the tensile test and the shock test, the authors are not prepared to say that there is no relation between the alternating-stress test and the shock test, because, although there are differences in the disturbance of the metal in the vicinity of the fracture, the radical phenomena ("dislocation" and "cleavage") are the same. The maximum shock strength for the particular grade of steel containing 0·25 per cent. of carbon is about 30 blows, as gauged by the authors' machine. Although 30 blows may be a fair figure, such steel cannot be relied upon to give this always. More than 30 blows is rarely reached with this steel in its normal condition, while it is a very common occurrence for the number to be considerably below this. Similar remarks apply to steels of other grades. With the usual factors of safety considered by authorities to be sufficient, they find that for those parts subjected to more or less shock there is a grave risk of their breaking under the modern conditions of high speeds. The authors express the opinion that the comparative immunity from failure that does exist in machinery is due to the liberal data on which the designer usually bases his calculations and to the "extra allowance for practical purposes" that creeps in all

designs, thus bringing up the real factors of safety to a figure considerably higher than that primarily intended to be used. If, however, the increasing desire to keep scantlings down to a minimum is to be realised, security can only be obtained by ensuring that the steel used shall have the maximum shock strength for its grade.

Further, the majority of steel users require that they shall be able to use an ordinary steel as supplied to them, and without annealing, tempering, or other heat treatment. The authors therefore urge that the engineer should demand of the steel maker a greater attention on his part to produce and supply the ordinary grades of steel with a more uniform "shock" quality.

The Nature and Peculiarities of the Fracture of Mild Steel by Shock.—With good steel—namely, steel with a practical minimum of the recognised injurious elements—maximum toughness goes with a finely crystalline structure—that is, one with grains of a minimum size. The following remarks apply to mild steels in the pearlitic condition, and this condition may be roughly defined as follows:

Normal "mild steel" is a mixture of crystalline ferrite or nearly pure iron grains, and pearlite grains more or less of a crudely crystalline form. This pearlite, which is the eutectic or mother liquor, and solidifies last, may be considered to partake of a crystalline nature when, as is generally the case, the alternate layers of ferrite and composite carbide lie parallel to one another in definite patches.

Fig. 3 will help to illustrate this point. It is a section of an almost "saturated" steel, the only free ferrite being the thick cellular envelopes (white), while the remainder (dark) is pearlite. It will be noticed in them that the nucleus of each cell is not always of the same orientation, some being divided into lumps of different orientations. For the purpose of definition each of these lumps will be considered to be a pearlite crystalline grain or "pearlite crystal."

The carbides of iron and manganese that are found in "normal" steels are known and admitted to be very hard and extremely glass-brittle substances. Although it is generally recognised in practice that for tools to have to stand heavy blows, saturation-steel—that is, steel that is wholly pearlite in its soft natural condition—is the toughest, yet this steel is an exceedingly brittle substance when compared with a low-carbon or nearly all ferrite steel. Since low-carbon steel or nearly pure ferrite is, when not tampered with, as is often the case in that singularly variable process called annealing, a very ductile and tough leathery substance, the natural conclusion come to is that the increase in minimum brittleness as the carbon scale is ascended is due to the presence of pearlite. Although the average size of granule for the different grades of steel experimented with has not been measured, the authors have obtained by selection, and heat treatment where unavoidable (still retaining the pearlitic condition), a number of pearlitic steels in which the grains are approximately a minimum for the particular scantlings involved. It is, of course, to be expected that brittleness in steel increases with the carbon content, but the authors are convinced that the falling off in this respect is far more rapid than the majority of engineers are aware of. And further, they believe that this has been in a great measure unobserved, owing to the prevalence of the tensile as the only test; and they are also led to this by the fact that the very toughest "fancy" steels (as distinguished from the natural or normal pearlitic steels) are often produced from what is more or less equivalent to high-carbon steels, such, for example, as the nickel alloys, where the ferrite is almost wholly displaced by a composite mixture.

The authors have come to the conclusion that given a certain percentage of carbon in steel: (1) it is impossible in any given mass to produce a grain below a certain size and still preserve the eutectic as pearlite; (2) there is a minimum brittleness upon which it is impossible to improve while still retaining the pearlite eutectic; (3) this brittleness increases very rapidly with the increase of carbon, especially at or about the "mild" region.

From the results of numerous experiments they arrived at the results shown on diagram, Fig. 1, which gives approximately relative values of minimum brittleness or maximum toughness under shock. For instance, it may be expected that with articles of approximately the same scantlings, and in their pearlitic condition, those having 0·2 per cent. carbon will be five times tougher to resist shock than those with 0·3 per cent. This diagram is intended to apply to forged or rolled steel and not steel castings—at any rate not such as usually supplied. Since in a "saturated" steel the line of fracture is necessarily through pearlite, an exceedingly brittle substance compared with ferrite, the next natural conclusion from this is that the line of fracture will be in all cases through as much pearlite as it possibly can. There also appears to be yet a prevalent idea that fracture of any kind takes place more or less along the crystalline grain junctions.

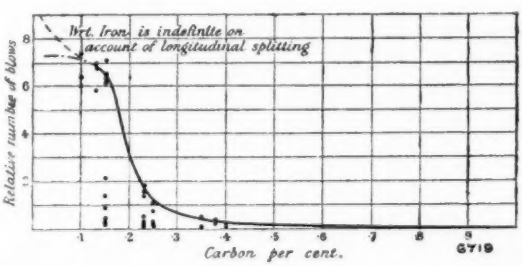


FIG. 1.—CURVE OF MAXIMUM SHOCK STRENGTH OF COMMERCIAL "PEARLITIC" STEELS (FORGED AND ROLLED QUALITY).

The series of outlined sections show—First, that in any grade of steel of the range under consideration the line of fracture does not go through as much pearlite as possible; further, that it distinctly avoids doing so, but really goes through as much ferrite as possible. Secondly, that fracture through the ferrite crystalline junctions is extremely rare, and really is practically always through cleavage planes.

The authors have also observed that the fracture through pearlite is not junctional—that is, between the lumps—neither is it as a rule parallel to the laminations, but appears to follow an erratic course both in saturated and undersaturated steels; in the latter the controlling agent is evidently the ferrite, but in the former the reason is obscure.

It will thus be seen that by the first statement above there is a contradiction to the second natural conclusion arrived at (above), that fracture would of necessity take place through a maximum of pearlite.

There is also an apparent contradiction to the first natural conclusion that increased brittleness is the outcome of an increase in the quantity of pearlite. To this latter it is obvious, of course, that there is no real contradiction, seeing that carbon is the only variant. Suppose, for instance, that steel were compared to a mixture of soft putty and glass, fracture by a steadily applied load would surely be expected to go through the putty. But would it if broken without appreciable deformation and by a repeated or single pounding sort of action? Moreover it must be borne in mind that pearlite itself consists of alternate layers of cementite and ferrite, or more putty and glass; so that supposing cohesion between the putty and glass to be perfect, the authors are inclined to expect the fracture to go through the putty of one of the "sandwiches," and not through the putty mass when subject to shock; this, however, is precisely what does not happen in steel. Further, there is the phenomenon of crystallisation which is not present in the putty. The analogy would, however, serve fairly well for failure by tension, which is all the more reason why it must be viewed with suspicion here, since the authors have found that there is absolutely no connection between tensile strength and shock strength.

The feature that distinguishes the fracture under tension from the fracture under shock is that in the latter case there is an almost total absence of "slipping" right up to the actual fracture itself. As Prof. Ewing and Mr. Rosenhain have shown,* strain beyond the elastic limit is associated with an internal slipping within the crystals themselves; also that this is the phenomenon that accompanies the fracture of a test-bar submitted to an alternating stress (rotating method) below the elastic limit for a considerable space in the vicinity of the fracture.

Photographs accompanying the paper show sections through or near to the tension fracture as produced in the tensile-testing machine. The crystalline grains are therein seen to be very much drawn out, and the slip-bands are revealed throughout the entire fields shown.

The slip-bands in the interior can only be revealed by etching. The distinction between fracture by true alternating stress and by shock is not quite so clear in sections taken from the interior of the article. Since there is little or no drawing out of the crystalline grains, it follows that separation by consecutive or progressive slipping will not be nearly so drastic as in the case of the tension specimen. It should therefore be much more difficult to obtain a slip-band appearance by etching a specimen broken by an alternating stress considerably below the elastic limit. Nevertheless, on comparing the two specimens, it appears that the fracture by alternating stress is accompanied by small cracks and fissures in its immediate vicinity to a much greater extent than is the case with the fracture by shock. Further, slip-bands (or minute parallel fissures) are often visible close to the edge of the alternating fracture, but they have never been discovered near a shock fracture.

The results are summarised as follows: (1) Impact test-bar fracture is through ferrite, and has no slip-bands; (2) fractured bolts, etc., show no drawing out or slip-bands; (3) alternating stress (rotating) test-bar fracture is through ferrite, with external slip-bands in profusion, and internal slip-bands sometimes visible, but there is no drawing out of crystals; (4) tension test-bar fracture is accompanied by slip-bands in profusion, and with the crystals very drawn out; (5) fracture by direct intermittent stress is highly improbable.

The only conclusion that seems possible from the above is that the fracture and method of producing the fracture is of a similar nature in the articles that break mysteriously and in the impact test-bars broken by a number of blows—that is, by a spreading crack.

Reverting to the consideration of the path of the fracture under shock for the explanation of the phenomena observed, the authors do not think a more obscure reason than the simple one of the mechanical effect of contraction when cooling need be sought. They made a number of experiments on a mass of saturated steel—that is, one consisting exclusively of pearlite—and on a mass of very low-carbon steel (having less than 0·1 per cent. Carb.), one to all intents and purposes of wrought-iron or ferrite without any slag in it. The experiments, which were conducted in a precisely similar way throughout, showed the coefficient of expansion of pearlite to be higher than that of very low-carbon steel or ferrite. The results, which are shown in Fig. 2, embrace a range of about 343 degs. Cent. The authors believe these results to be correct, relatively if not absolutely.

It is a well-known fact that all irons and steels expand from the molten to the plastic state, and then contract from the plastic state to solid and until cold. It is unnecessary to take refuge in either of the disputed theories of the formation of steel to assist their explanation. The partisans of each school unquestionably admit the existence of the critical temperatures Ar_1, Ar_2, Ar_3, and Ac_1,

* Proceedings, Inst. Mechanical Engineers, 1901, Part I, p. 249.

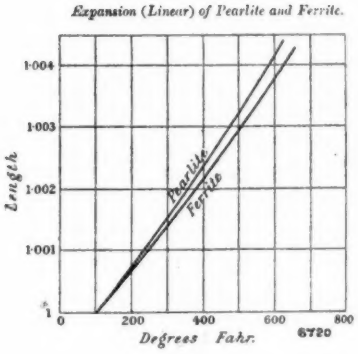


FIG. 2.

Ac_2, Ac_3, so that in any case three principal periods will be observed during the cooling :—

(1) From the molten state to Ar_3.
(2) From Ar_3 to Ar_1.
(3) From Ar_1 to cold.

Above Ar_3 it is self-evident by any theory that there can be no mechanical action that can have any bearing on the present question, for neither of the characteristic cold components of the steels under discussion can have yet taken final form.

Taking the second period, Ar_3 to Ar_1, it is highly probable that there are changes of volume of the components that take place simultaneously with the chemical or allotropic changes, whichever may occur; but the range of temperature is small and the volumetric changes of the components will be sudden, so that either there will be approximate mutual action or else gaps will be formed. The former seems to be the more probable, as there is no evidence of any gaps under the microscope, and their existence is not confirmed by any of the peculiar ways of steel fractures under various forces. Further, the phenomenon of expansion during plasticisation at the higher temperatures (much above Ar_3) may be present in the carbon-laden components at their lower plasticisation temperatures which occur in the region between Ar_3 and Ar_1. But between Ar_1 and cold there is a very long period when the pearlite is constantly contracting at a difficult rate from the ferrite.

Supposing that the authors' relative coefficients of expansion be correct, then, since the pearlite is contracting at a greater rate than the ferrite, it means that it is acting as a sort of hydraulic expander to the ferrite instead of a hydraulic press, and this effect will increase with the increase of carbon. There would therefore be an increasing tendency to hollowness in each individual ferrite grain in much the same way that a piece of lead, for example, sinks down when cooling, and with this tendency they think it is quite reasonable to suppose that there is a corresponding tendency to easy separation through the grain either individually or in series. And in the case of the higher carbon steels where the quantity of ferrite is small, there would alternatively be an increasing tendency to separation between the ferrite and pearlite.

A deduction is therefore arrived at that harmonises the apparently anomalous facts that the line of fracture avoids going through pearlite; that the line of fracture avoids going through the junctions; and that brittleness increases with the carbon content. And further, the larger the crystalline grains the greater the weakness; which is not only confirmed by their numerous test-bars examined, but by the intensely brittle results that are produced by long annealing. Supposing that the coefficient of expansion of ferrite be greater than that of pearlite, there would still be the tendency to openness in the ferrite, but it would be a decreasing tendency with the increase of carbon. On the whole, therefore, the authors think their experiments and observations are confirmatory.

Fig. 4 is an outlined section from a piece of good cast steel that has been "heat-treated," this process being conducted subsequently to the usual annealing at the maker's works. The heat-treatment consisted of—

(1) Heating to about 800 degs. Cent. (1,472 degs. Fahr.) quickly.
(2) Quenching in oil.
(3) Reheating to about 700 degs. Cent. (1,472 degs. Fahr.) quickly.
(4) Cooling naturally (about half an hour).

The structure has developed curiously and instructively, for it illustrates three points. The

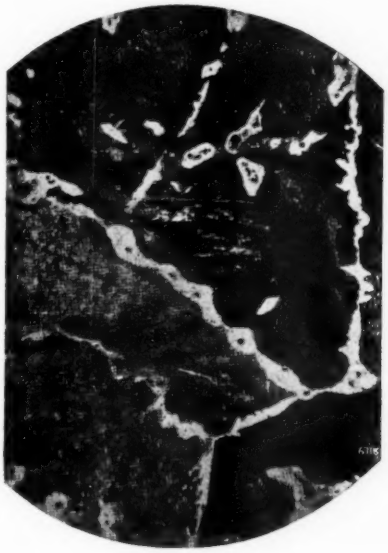


FIG. 3.—CAST STEEL, ILLUSTRATING THE GRANULATION OR QUASI-CRYSTALLISATION OF PEARLITE.
White = Ferrite. *Dark* = Pearlite.

dark masses are a fine-grained steel with about 50 per cent each of the ferrite and pearlite. The dark line running through the field is the actual line of fracture under shock. The bright areas are comparatively grossly crystalline ferrite. It will be seen here: (1) that the line of fracture does not go through the fine-grained steel, which indicates that fineness of grain is necessary for toughness; (2) that it goes almost exclusively through the ferrite; (3) that it does not go through the crystalline grain junctions but through cleavage planes.

Figs. 5 and 6.—These are from the same piece of steel as the last, but it has not been "heat-treated," and is just as cut from the casting, which was one weighing about ¼ ton. The structure here is what may be termed "inclusively homogeneous," and is of the same character as of the forged steels under consideration, except that it is very much more gross. It will be seen that, although with a steel containing this fairly large quantity of eutectic there are necessarily portions of the pearlite areas fractured through, there is on the whole a general and distinct avoidance of the pearlite.

Figs. 7 and 8.—From medium-carbon steel of Admiralty quality exhibits the preference of cleavage to junctional ferrite fracture.

Figs. 9, 10, and 11.—From low carbon steels (Carb. about 0·15 per cent.) fracture has, of course, to be mainly ferritic, but a pearlitic fracture is extremely rare, if not entirely absent. (Pearlite-ferrite junctional-fracture is fairly common.)

In the foregoing the subject-matter has been confined to the strength, etc., of steel in its natural condition, or that condition produced by the comparatively slow cooling process of ordinary manufacture. The shock strength of "treated" steels, however, is a matter of equal, if not greater, importance. The authors have not had the time nor facilities for conducting a complete series of experiments with these steels, but they have done quite sufficient to be assured of the fact that the shock strength of oil-quenched mild steels par-

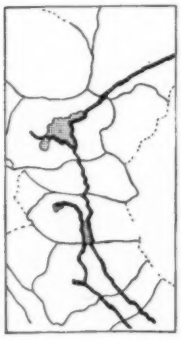


FIG. 4

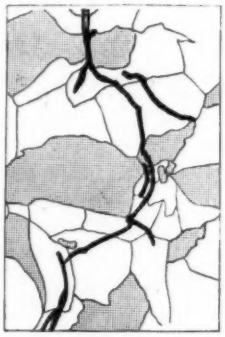


FIG. 5.

FIG. 6.

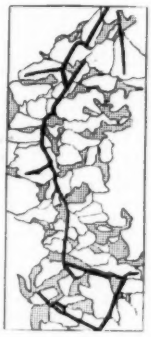


FIG. 7.

FIG. 8.

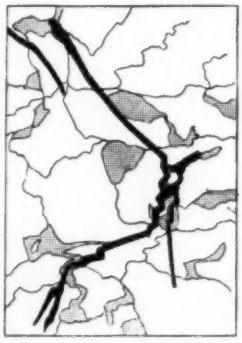


FIG. 9.

FIG. 10.

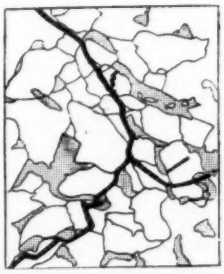


FIG. 11.

ticularly is not increased a mere matter of 20 per cent. (720 degs. Cent. in oil, 0·25 Carb.) to 130 per cent. (1,200 degs. Cent. in water), as is the case with the tensile strength, but on an average 500 to 600 per cent. more than the shock strength of the natural steel in its *best* condition. Moreover, oil-quenching appears to possess the highly important property of "levelling up" the shock strength of steel to a fairly constant value.

Thus there may be two similar articles made of the same grade of steel, the one coarse and brittle and the other fine and tough, and possessing a maximum shock strength. Oil-quenching will increase the strength of both to a common value, the increase in the one case being perhaps several thousands per cent. and in the other the 500 or 600 per cent. above referred to.

They think that practice with such things as gun-barrels shows this also very clearly, and they have no hesitation in saying that whereas the tensile-testing machines practically make no distinction between the steel that is utterly unfit and that which is eminently fit for the parts of a machine subject to shock or vibratory stresses, the drop-testing apparatus does most certainly, and without fail, make the discrimination; and further, that wherever the drop-testing machine shows a steel to be good the tensile-testing machine corroborates it. Therefore it may be concluded that while the drop-testing machine is a certain and reliable guide to the maker of such structures, it is equally the friend of the producer of other structures, subject only to tension or compression steadily or constantly applied.

On Power Gas.

By Ferd Fischer.

Zeitschrift des Vereines Deutscher Ing., Oct. 29th, 1904.

The following reaction occurs in the gasification of carbon, under the action of oxygen, carbonic acid, and water vapour:

	Reaction.	Heat in Furnace.	Calorific value of gas obtained.
		Units.	Units.
1	$C + O_2 = CO_2$	97,600	
2	$C + O = CO$	29,400	6,8200
3	$C + CO_2 = 2\,CO$	− 38,800	136,400
4	$C + H_2O = CO + H_2$	− 28,800	126,400
5	$C + 2H_2O = CO + 2\,H_2$	− 18,830	116,400

12 kgs. of carbon, on being burnt to carbonic acid, thus yield 97,600 heat units, while in gasefying 12 kgs. of carbon by 44 kgs. carbonic acid (according to 3) 38,800 heat units have to be supplied in the furnace, the 56 kgs. carbon monoxide obtained, possessing a calorific value of 136,400 heat units. In the gasification of carbon the heat is only evolved by free oxygen, whereas bound oxygen absorbs heat. The heat exchanges in reactions 2 and 4 have been calculated from combustion values of carbon and carbon monoxide.

Deville was the first to show that on carbon monoxide being passed over soot, carbon dioxide was formed at the temperature of softening glass in very small amounts, and at temperatures below the melting point of silver at very high rates, carbon being given off, according to $2CO = C + CO_2$ 38,800 heat units being freed according to equation 3. Mallard and Le Chatelier have shown that carbonic acid is decomposed to an appreciable amount only at a temperature of 2,000 degs. Cent. According to researches by C. Langer and V. Meyer, carbon monoxide is partly decomposed at about 1,700 degs. Cent., while carbon is given off: $2CO_2 = C + CO_2$. Carbonic acid can be heated in platinum vessels up to about 1,700 degs. without decomposition. On leading oxygen slowly above retort coal Mr. Lang obtained exclusively carbonic acid at 500 degs. Cent. According to Naumann and Ernst, increasing amounts of carbon monoxide are formed with increasing temperatures on leading air slowly above coke, while at 1,000 degs. it is formed exclusively.

According to Boudouard a mixture of 27 per cent. carbon monoxide and 73 per cent. nitrogen, on being led above coal at 800 degs., gives 0·6 per cent. carbonic acid. Carbon monoxide, on being heated with charcoal to 550 degs., gave, after 1 hour, 94 per cent. of carbonic acid and 6 per cent. of carbon monoxide. Varying figures were obtained on heating carbonic acid with charcoal according to the temperature, as well as the nature and shape of the fuel, it being shown that the rate of the reversible reaction

$$2\,CO \rightleftharpoons C + CO_2$$

is dependent on the above factors. Anyhow a long time is required for the state of equilibrium to be reached.

Hempel tried to utilise air rich in oxygen (50 per cent. oxygen) for generating producer gas, and very large amounts of carbonic acid were obtained in spite of the very high temperatures. Experiments by Wieland showed the ratio of carbon monoxide to the carbonic acid to increase with the temperature and duration of contact.

It has been known for a long time that water vapour, on being led above incandescent coal, forms hydrogen, carbonic acid, and carbon monoxide. The gas thus obtained contains, according to Bunsen, one volume of carbon monoxide for each two volumes of carbonic acid. The action of water vapour on brown coal coke, according to experiments by the author, begins at about 400 degs., and the action on gas coke at about 530 degs., according to Lang's experiments. The gas issuing at 630 degs. in a slow stream has the following composition.—Carbonic acid 20·4 per cent., carbon monoxide 0·9 per cent., hydrogen 39·8 per cent., nitrogen 38·9 per cent.

Retort graphite in a stream of water vapour gave—

100 ccm. gas accumulated in	Temperature. °C	Composition of gas in %. CO_2	CO	H	N
24 hours	814–861	13·4	8·8	56·0	21·8
8 ,,		16·2	10·8	62·2	10·8
1¾ ,,	861–954	22·5	6·1	68·0	3·4
15 min.		20·0	10·3	68·3	1·4
8 ,,		19·4	13·7	65·7	1·2
8 ,,	954–1054	17·5	16·0	65·3	1·2
8 ,,		18·3	17·3	62·0	2·4
8 ,,		18·4	16·9	62·1	2·6

Harries, on leading water vapour through a porcelain tube filled with coal fragments, obtained the following figures :—

Gas steam per min. litres.	Temperature. °C	CO_2 vH	CO vH	H_2 vH	H_2O vH
0·9	674	3·84	0·63	8·41	87·12
1·8	758	9·23	2·67	22·28	65·82
3·66	838	11·29	6·04	28·68	54·09
3·28	838	12·11	7·96	32·77	47·15
5·3	861	13·33	11·01	36·48	39·18
6·3	954	5·66	32·70	44·43	17·21
6·15	1010	1·45	48·20	47·30	3·02
9·8	1060	1·25	46·31	48·84	3·68
11·3	1125	0·60	48·34	50·73	0·303

O. Hahn investigates the equilibrium—

$$CO_2 + H_2 \rightleftharpoons CO + H_2O.$$

A quartz tube filled with platinum foil or platinum sponge, and placed in a resistance furnace, was used, when the following figures were obtained for the ratio :—

$$K = \frac{CO_2\ H_2O}{CO_2\ H_2}$$

(a) starting from CO_2 and H_2O

886°	986°	1086°
K = 1·19	1·54	1·95

(b) starting from CO_2 and H_2

1005°	1205°	1405°
K = 1·68	2·10	2·49

It is advisable, according to the author, to preheat the air by the exhaust gases. It is very important, in order to obtain a satisfactory gas, to choose a proper ratio between the water-vapour and air. This ratio is highly variable in suction gas producers, which disadvantage is, however, compensated for by simplicity of operation in the case of small-sized plants. In large-sized plants the author recommends pressure-gas operation. In such plants bituminous coal would be preferable to anthracite, as the cost of cleansing is greatly compensated for by the production of ammonia.

The utilisation of peat has been much spoken of lately. The distillation and gasification of peat with a view to obtaining heating-gas, paraffin, oil, ammoniac and methyl alcohol or peat coal was tried as far back as in 1849 by Reece. The experiments made by L. C. Wolff on the utilisation of peat, according to the M. Ziegler process, have been discussed fully in the August issue of the ENGINEERING REVIEW (pp. 148, 149). The carbonisation oven used in connection with these experiments, was an upright retort of an oval cross section, the lower part of which was made of fire-proof brickwork, and the upper part of cast-iron. The author takes, however, exception to some of the conclusions drawn by Wolff.

Peat-gas producers were first introduced into practice by Ebelman in 1842. These producers, like those at present used in Sweden, were operated without any supply of steam. In connection with gas-motors, this kind of gas was first utilised in 1883 in Düneberg, near Hamburg. According to recent data supplied by the Gasmotorenfabrik Deutz, two kinds of peat, from Hanover and Giengen respectively, gave power gas of the following composition :

	Hanover.	Giengen.
	per cent.	per cent.
Carbonic acid	5·7	6
Carbon-monoxide	30·6	30
Methane	5·1	2·4
Hydrogen	6·1	10
Nitrogen	52·5	51·6

For each effective h.p.-hr. 1·2 and 1·1 kgs. of peat was used respectively. Similar statements are made by the Körting firm.

Lutes and Cements.

By SAMUEL S. SADTLER.

Proceedings of the Engineers' Club of Philadelphia, October, 1904.

WHAT is recorded in the literature of this subject is not very dependable, and is, in most cases, vouched for by no one. Further, the engineering handbooks are practically barren of any information on this subject.

Luting and cementing may be classified as follows :—

1. *Waterproof Compositions.*—Of use to engineers are the asphalt fluid coatings for reservoir walls, concrete foundations, brick, wood, etc.

Asphalt only partly dissolves in petroleum naphtha, but heated in a steam-jacketed kettle and not thinned out too much, a mixture of the two may be obtained in which the part of the asphalt not dissolved is held in suspension. Asphalt is entirely soluble in benzol or toluol, which are about the cheapest solvents for all the constituents of asphalt. Tar and pitch are sometimes used in this connection, but tar contains water, light oils, and free carbon, and does not

wear as well as good refined asphalt; and pitch contains free carbon, which is sometimes objectionable when thinned out with a solvent. The asphalt alone is somewhat pervious to water, and this is improved by adding about one-fourth its weight of paraffin, and made better if in addition a little boiled linseed oil is added also. For thicker compositions, where body is required, asbestos, stone powder, cement, etc., may be added as fillers.

Lutes of linseed oil thickened with clay, asbestos, red or white lead, etc., are waterproof if made thick enough. These are much used for steam joints.

Flaxseed meal made into a paste with water is often serviceable, the oil contained serving as a binder as the water evaporates.

2. *Oil-proof.*—The most useful lute for small leaks, etc., is the well-known "hektograph composition," as follows:—

Good glue or gelatin	2 parts.
Glycerin	1 part.
Water	7 parts.

This is applied warm and stiffens quickly on cooling. Another very useful composition is a stiff paste of molasses and flour. Another preparation impervious to oil vapours is the "flaxseed poultice," mentioned in Sec. 1, which is proof to oil vapours.

One of the strongest cements, and one which is really oil-proof, water-proof, acid-proof, and proof to almost everything, is a stiff paste of glycerin and litharge. These form a chemical combination and set in a few minutes. If a little water is added, it sets more slowly, which is often an advantage. It is mixed when required for use. Plaster of Paris wetted, by itself, or mixed with asbestos, straw, hair, etc., is useful. A solution of silicate of soda made into a stiff paste with carbonate of lime, gets hard in six to eight hours.

3. *Acid-proof.* — The asphalt compositions already mentioned, compositions of melted sulphur with fillers of stone powder, cement, sand, etc.; also the following, which withstands hydrochloric acid vapours:

Rosin	1 part.
Sulphur	1 ,,
Fire clay	2 parts.

The lute composed of boiled linseed oil and fire-clay acts well with most acid vapours. The composition of glycerin and litharge referred to is useful in this connection, especially when made up according to the formula

Litharge	80 pounds
Red lead	8 ,,
"Flock" asbestos	10 ,,

fed into a mixer, a little at a time, with small quantities of boiled oil (about six quarts of oil being used). Sockets joined in 3-in. pipes carrying nitric acid were caulked with this, and showed no leaks in nine months.

A particularly useful cement for withstanding acid vapours, being also tough and elastic, is:

Crude rubber, cut fine	1 part.
Linseed oil, boiled	4 parts.
Fire-clay	6 ,,

The rubber is dissolved in carbon disulphide to the consistency of molasses and then mixed with the oil. Other examples of acid-proof cements are as follows:—

"Black putty," made by intimately mixing equal portions of china-clay, gas-tar, and linseed oil. The china-clay must be well dried by putting over a boiler, etc. The author says that it is probable that anthracene oil might be used to advantage instead of gas-tar, for reasons which he stated in referring to asphalt lutes. It seems, however, that soft pitch, or better still, a semi-liquid asphalt or naphtha would be best.

Barytes cement is composed of pure, finely ground sulphate of barium, and is made into a putty with a solution of silicate of soda. This sets very hard when moderately heated, and is then proof against acids. The gravity of the silicate of soda should be between 1·2 and 1·4, 24 degs. to 42 degs. Beaumé. If too thin, it does not hold; and when thicker than 1·4, it expands and breaks.

4. *Hydrocarbon Gases.*—Compositions of plaster and cement, the former setting more quickly, are used. Also compositions of casein, such as:

Finely powdered casein ...	2 parts.
Fresh slaked lime	50 ,,
Fine sand	50 ,,

Water is added, when used, to form a thick mush.

Various mixtures of silicate of soda are employed in which the thick silicate is absorbed in some inert material, as clay, sand or asbestos.

5. *Chlorine.*—The best and only reliable compositions are a few made with Portland cement, and the following is much used for electrolytic and chemical plants:

Powdered glass	1 part
Portland cement	1 ,,
Silicate of soda	1 ,,
A small amount of powdered slate.	

This lute is said to stand acid and alkali, as well as the influences of chlorine. Linseed oil made into a paste with fire-clay serves for a time.

6. *Elastic cements.*—The various cements containing rubber are elastic, if it is in a predominating amount; many containing boiled linseed oil and the hectograph composition already mentioned are quite elastic. The rubber-linseed oil cement, given under Sec. 3, is very tough and useful for nearly all purposes except when oil vapours are to be confined. The most useful single-rubber lute is probably the so-called Hart's india-rubber cement. Equal parts of raw linseed oil and pure masticated rubber are digested together by heating, and this mixture made into a stiff putty with fine "paper stock" asbestos. It is more convenient, however, to dissolve the rubber, first in carbon disulphide, and after mixing the oil with it, to let the solvent evaporate spontaneously.

7. *General Purposes.*—One of the most useful is plaster of Paris, and especially when mixed with asbestos, straw, flush trimmings, hair, broken stone, etc., used according to temperature, strain, and other conditions. A putty of flour and molasses is a good composition to keep in a works ready for quick application when needed. It serves almost any purpose at moderate temperatures for a time. Casein compositions have great strength.

White of egg made into a paste with slaked lime is strong and efficient, but must be used promptly, on account of its quick-setting qualities.

8. *Marine Glue.*—This can be purchased almost as cheaply as made. The rubber must first be dissolved in carbon disulphide or turpentine before mixing with the heated combination of the other two ingredients. Its uses are well known.

Crude rubber	..	...	...	1 part.
Shellac	...	...	...	2 parts.
Pitch	...	...	...	3 ,,

9. *Gasket Compositions.*—Of course, almost any cementing substance may be used with rings of asbestos, etc., for gaskets, but there are some that I have used, and which I have known others to choose, especially for that purpose.

With regard to asphalt, tar, pitch and petroleum rssiduum, I would recommend soft or hard pitch, as may be desired, because there are no light oils or water to go off at low heats, and the free carbon and compounds very high in carbon are good fillers to asbestos gaskets at high temperatures. Silicate of soda by itself is much used, but is sometimes advantageously mixed with casein, fine sand, clay, asbestos, carbonate of lime, caustic lime, magnesia, oxides of heavy metals, such as lead, zinc and iron, and powdered barytes. A few that might be selected are—silicate of soda and asbestos; silicate of soda, asbestos and slaked lime; silicate of soda and fine sand; silicate of soda and fire-clay.

10. *Machinists' Cements.*—These are the well-known red and white leads. The red lead is often diluted with an equal bulk of silica or other inert substance so as to make it less powdery. The best way to do this, however, is to add rubber or gutta-percha to the oil as follows:—

Linseed oil ...	...	...	6 parts by weight.
Rubber or gutta-percha ...	1 part	,,	,,

The rubber or gutta-percha is dissolved in sufficient carbon disulphide to give it the consistency of molasses, mixed with the oil, and left exposed to the air for about 24 hours. The red lead is then mixed to a putty. Oxide of iron makes a less brittle cement than red lead.

11. *Leather Cements.*—(For leather belting.) (1) Equal parts of good hide glue and American isinglass, softened in water for 10 hours and then boiled with pure tannin until the whole mass is sticky. The surface of the joint should be roughened and the cement applied hot. (2) One kilo of finely-shredded gutta-percha digested over a water-bath with 10 kilos of benzol, until dissolved, and 12 kilos of linseed-oil varnish stirred in. (3) Seven and one-half kilos of finely-shredded india-rubber are completely dissolved in 10 kilos of carbon disulphide by treating whilst hot, 1 kilo of shellac and 1 kilo of turpentine are added, and the hot solution heated until the two latter ingredients are also dissolved.

Another one:—

Gutta-percha ..	...	...	...	8 ozs.
Pitch ...	...	...	...	1 oz.
Shellac	...	...	...	1 ,,
Sweet oil	...	...	...	1 ,,

These are melted together.

12. *So-called Iron, Stone, and Crucible Cements.*—These are all hard, stone-like compositions. The oxychloride cements, consisting essentially of oxychlorides of magnesium and zinc, are very hard, and are much used in engineering construction.

Stone Cements:

Zinc oxide or magnesium oxide	...	2 parts.
Zinc or magnesium chloride ...	...	1 part.
Water to make a paste.		

When dry, these become very hard and strong. Powdered stone is generally used as a diluent.

Iron Cements.—When iron in a fine state of division, as in fresh filings or cast-iron borings that have been powdered, is mixed with an oxidising agent, such as manganese dioxide or a substance electro-negative to iron, such as sulphur, in a good conducting solution like salt or sal-ammoniac, galvanic action sets in very rapidly, and the iron swells by forming iron oxide, and cements the mass together. It is best diluted with Portland cement. A formula which the author gives from memory is:—

Iron filings	..	...	...	...	40 parts.
Manganese dioxide, or flowers of sulphur				...	10 ,,
Sal-ammoniac	...	...	...	...	1 part.
Portland cement ..	...	...	...	...	20 to 40 parts.
Water to form a paste.					

These cements are used extensively in foundries, etc.

The Distribution of Electrical Energy.

By JOHN F. C. SNELL, M.Inst.C.E.

Proceedings of the Institution of Civil Engineers, November 22, 1904.

AFTER dealing with the limits of pressure as defined by the Board of Trade, and the results of the work of the Engineering Standards Committee in settling upon standard periodicities, the systems of supply are thoroughly criticised, and the single-phase system is set aside as being inapplicable for general supply, as is also the direct-current high-tension system. The author is of opinion that the distributing systems which are likely to be adopted in the future are:—

1. Direct-current, two, or three-wire, for small districts.
2. Single-phase high-tension for railways.
3. Two-phase high-tension generation and low-tension distribution (for existing single-phase systems of general supply).
4. Three-phase high-tension generation and direct-current low-tension distribution (for existing direct-current systems in large districts, and for railways of short length).
5. Three-phase high-tension generation and low-tension three-phase or six-phase distribution (for entirely new and large districts).

Diagrams accompanying the Paper demonstrate the economical radii of supply by direct current at 500 volts for different loads transmitted, and by the high-tension sub-station method, the result being that above the undermentioned distances the high-tension method is more economical, viz. :—

Kilowatts.				Economical Radius.
250	...	...	...	1·6 mile
500	...	...	...	1·25 ,,
1,000	...	...	...	1·06 ,,

With regard to the effect of storage at sub-stations, the author believes that storage will be more largely resorted to in the future; and figures are given in support of this view. He then proceeds to discuss the economical limit of pressure for high-tension supply by underground cables; and gives curves to show that for general purposes, in Great Britain, 6,600 volts is, approximately, the economical pressure. The effect of the cost of insulation of extra-high-tension cables is also discussed. The paper next deals with the cost of overhead transmission of high-tension currents, and reasons for fixing upon a pressure of 20,000 volts in this country are given.

The various methods of distributing energy at low pressure are classed as follows :—

I.—*Conduit or Draw-in System.*

1. Bare-copper-strip systems, strained and unstrained.
2. Cables insulated by india-rubber, vulcanised bitumen, or other dieletrics drawn into stoneware casings, Callender-Webber bitumen casings, fibrous conduits, cement casings, and cast-iron or wrought-iron pipes.

II.—*Buried or Solid System.*

1. Vulcanised bitumen, dialite or other insulated single cables, laid in iron, stoneware, or wooden troughing, and surrounded by molten bitumen or pitch.
2. Concentric cables, paper insulated, and lead covered, laid in the same manner.
3. Single-phase or concentric cables, each protected by its own sheathing of steel tapes or wires, laid direct in the ground.

The relative merits of these systems are fully discussed, and a curve is given showing the respective capital costs of the systems.

The author then deals with the systems of distribution adopted in tramway construction, and their relative advantages and disadvantages.

The question of fusing the general network, and the fixing of section-boxes is gone into fully, the author deciding against fuses, except in concentric networks, and strongly advocating the use of section boxes for sub-dividing the network.

The Paper concludes with some particulars of the supply of electrical energy to short- and long-distance railways. The author believes that a modification of the present third-rail system will remain with short-distance railways, and that improved methods in the application and control of single-phase currents will be adopted for long-distance railways.

Centrifugal Fans.

By AUGUST J. BOWIE, JUN.

Proceedings of the American Society of Mechanical Engineers, December, 1904.

THE losses in a centrifugal fan may be classified in general as follows :—

Loss 1.—Sudden change of velocity. When the velocity of a body of air is suddenly increased or decreased there will be a loss of head, and consequently of energy, due to impact. The loss of head due to this cause will vary as the square of the speed of the air, provided the ratio of velocities be constant. Sudden change of velocity of any magnitude should be avoided as much as possible.

Loss 2.—Sudden change of direction. This loss is similar to the previous one, and should be particularly avoided where the velocity is great or where uniformity of velocity is desired for other reasons.

Loss 3.—Air friction. Loss of head due to this cause will vary as the square of the speed. In a properly-designed fan the losses due to the first three causes will be so proportioned that their sum is a minimum. This determines in part the design of the casing. Of course, the casing should be as smooth as possible, and all parts of the fan should be so constructed as to offer a minimum in the nature of obstructions to the flow of the air.

Loss 4.—Back slippage of air. This is a local circulation of air within the fan and casing. This loss may be cut down by reducing the area past which the air can circulate. This means a reduction of the mechanical clearance of the running parts of the fan. In the case of a closed runner the running rings should be so constructed as to render it difficult for the air to circulate past them. With centrifugal fans considerably more clearance is required than with centrifugal pumps, where water lubrication of the running rings allows the use of very small clearances.

Loss 5.—Eddy currents. In some fans this is quite a serious source of loss. To avoid this loss a thorough understanding of the action of air in motion is decidedly necessary.

Loss 6.—Bearing friction. This loss is of two kinds: First, that due to the natural friction of the dead weight of the fan, and, secondly, that due to lack of balance of the fan. The loss due to the latter cause is apt to be very serious, owing to the high velocities of revolution, and to impair very materially otherwise excellent results. It is perhaps needless to add that the losses due to bearing friction depend very much on lubrication of the

bearings, and that self-oiling bearings should by all means be used on such high-speed machinery. This is particularly true if there is any unbalance of the runner, when the bearing friction may be a comparatively large proportion of the total input.

A study of the flow of air is of great assistance in fan design. To attempt to make air flow in certain fixed paths without due consideration of whether it can be forced through those paths at a uniform velocity is certainly not the right way to approach the subject. The usual result of such a procedure is that the flowing air will not fill the channels through which it must pass, thus resulting in a very unequal distribution of velocity, and consequent loss in eddy currents and in other ways.

A graphical plot of the lines of flow and the velocities of the same is perhaps the best method of studying the action of air in motion. To obtain results suitable for plotting such a curve an anemometer is practically out of the question, being entirely too large to use for any such purpose, besides being open to other objections.

By means of a Pitot tube rough approximations may be made of the velocity of flow at any point. However, the pressures obtained will, in many instances, be so complicated by an existing state of pressure of the air as to render the readings of the gauge of little value as a means of indicating the actual velocity of the air. This, too, in cases where it would seem almost incredible that a state of pressure different from that of the atmosphere could exist.

With the idea of obtaining a suitable velocity gauge for air, which would be independent of any existing state of pressure, the writer designed the following apparatus. Two small brass tubes were soldered together side by side. Openings were made in these tubes, directly opposite to each other, 180 degs. apart. In order to have the holes as nearly opposite in direction as possible, they were formed by soldering a small piece of tube on the end of each tube, so as to form a kind of right angle turn. These pieces were then filed down so as to make the ends of the tubes practically no larger than the remainder of the tubes. Rubber tubing connected the other ends of the brass tubes to the two sides of a sensitive differential pressure gauge. The brass tubes were mounted so as to turn about their axis, in a suitable head provided with a scale, laid off in degrees The tubes themselves carried a pointer for the scale.

The idea of this apparatus was as follows. If a small tube, with an opening in one side, be placed in a body of fluid, flowing at a uniform velocity, normal to the tube axis, then the resulting pressure in the tube will be the sum of the static pressure of the fluid, and of the dynamic pressure of the fluid, impinging on the opening. According to theory, the dynamic pressure will vary from the pressure due to the velocity head, Pv, to $-Pv$, as the tube is revolved; being $+Pv$, when the opening is directly opposed to the flow of fluid; O, when the opening is 90 degs. from this position, and $-Pv$, when the opening is 180 degs. from the first position.

The tubes were to be placed in the path of flow

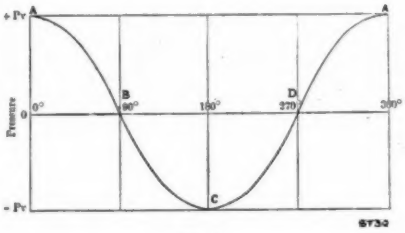


FIG. 1.

of air, and normal to the same. The static pressure would be equalised in each of the tubes, and the pressure difference would be due to dynamic pressure alone. This would vary as the tubes were revolved; being a maximum when the opening in one was directly opposed to the flow of air, and the other tube was in consequence subjected to the negative pressure due to the velocity of flow. Calling the static pressure Ps, the pressure in the first tube would be $Ps+Pv$, and the pressure in the second tube would be $Ps-Pv$. The pressure difference would be $2Pv$, a maximum. From this, the velocity could easily be calculated. As this maximum point of pressure difference would be at the flat portions A and C of the pressure curve, theoretically obtained by revolving a Pitot tube in a stream of air (see Fig. 1), it would be difficult to ascertain, at all accurately, the direction of flow therefrom. Hence, it was intended to use a zero method to attain this end. In other words, the direction of flow of air was to be found by equalising the pressures in the two tubes. This point of equal pressures would occur at BD, when the line of the openings in the tubes was normal to the line of flow of the air.

However, when the zero method was tried, the results were rather indefinite and unsatisfactory. In order to see the reason for this, a test was made utilising only one side of the double tube, and opening the other side of the differential pressure gauge to the atmosphere. The tubes were then revolved, and pressure readings and corresponding angular readings were taken. The result of this test is shown in the curve, Fig. 2. The

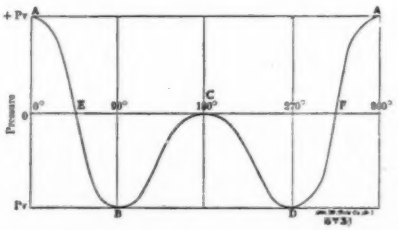


FIG. 2.

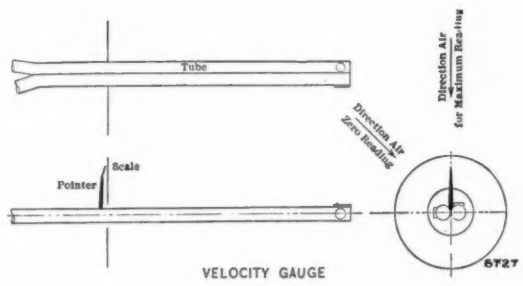


FIG. 3.

curve is in the nature of a W, having two maxima and minima. The point of maximum pressure is when the opening is directly facing the stream of flow. The points of minimum pressure are at right angles to this line of flow, while at 180 degs. from this line of flow is another maximum point. It has usually been considered that the last-mentioned point was a minimum, and that the points where the openings were normal to the line of flow would give readings independent of the velocity of flow. Instead of this, we find that the conditions are approximately that the point where the opening in the tube is opposed to the flow will give a pressure $Ps + Pv$; the 90 degs. points give $Ps - Pv$; while the 180 degs. point gives Ps. This statement gives a rough approximation, and will, of course, vary somewhat with the form of the tube. The reason why the apparatus had failed to work accurately on the 90 degs. point is apparent. B and D (Fig. 2) were these points, and except for the fact of being a zero method, it would have been impossible to have found two more unfavourable points for a differential reading.

Next, the two tubes previously used were shifted around 90 degs., so that the two openings were at right angles to each other, instead of being 180 degs. apart (see Fig. 3). The effect of this was that a maximum reading was obtained at AB or AD, and a zero reading at EF. This maximum reading was about twice as large as had been previously obtained; and the zero reading was at the most sensitive point on the scale, the slightest variation of angular position of the tubes making one pressure go up and the other fall rapidly. The gauge, as altered, became so exceedingly sensitive, that with the comparatively crude apparatus used, it was an easy matter to get the correct angle of flow of the air within ½ deg. The gauge was calibrated both for angular position and for pressure, by placing the tubes in a stream of air, flowing with a known velocity and in a known direction.

With the aid of this apparatus, it was a comparatively simple proposition to determine exactly what was going on at any point in an air path, not cut by moving vanes. By boring a small hole in a fan casing close to the periphery of the fan, it became possible to tell just how the air was leaving the runner of the fan, both as regarded velocity and direction. By mounting the tubes and head in suitable guides, readings could be taken across the face of the fan, and the surface distribution of air plotted out. In order to get the actual delivery at any point in the face of the fan, the velocity of air at that point should be multiplied by the sine of the angle that the direction of flow makes with

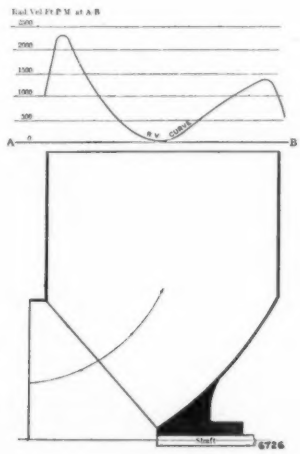


FIG. 4.

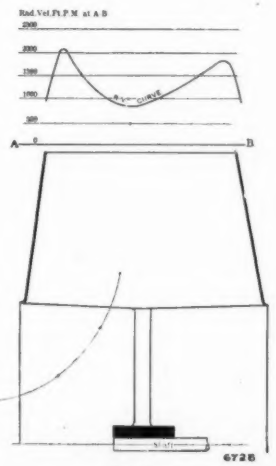


FIG. 5.

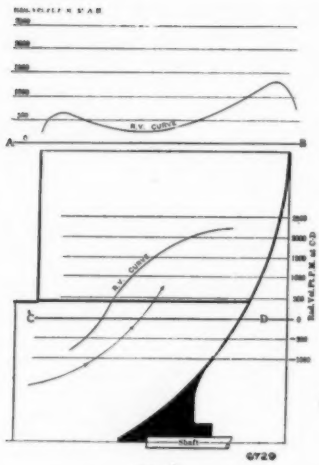


FIG. 6.

the tangent to the circumference of the fan at the point in question. By the proper use of this apparatus the presence of eddies may be discovered, and suitable provision may be made in the design of the fans to eliminate them.

The author has obtained some very peculiar results by applying this method of testing to obtaining the radial discharge from fans; and the radial discharge is the true criterion of the amount of air actually delivered from the periphery of the fan. In one case, a certain single-suction fan, when run beyond its capacity, gave all the discharge from the sides of the runner; the air in the centre of the face of the runner was actually on the point of starting to go the other way. This was an example of bad distribution of air.

A uniformly distributed flow of air is, of course, conducive to better results, though some fans show a fair efficiency in spite of poor air distribution. Waste space is a thing to be avoided in fan design. It serves merely as an aid to eddy currents, with their inevitable losses.

Figs. 4, 5, and 6 show some results obtained with various runners. The figures show half sections of the runners, and the radial velocities of discharge from the periphery of the same. Owing to the crudeness of the apparatus used, and to the fact that the tubes were, of necessity, some short distance from the periphery of the fan, to allow running clearance, the results are not accurate. Still, they show quite clearly some rather remarkable distributions of air. Fig. 6 shows, in addition to the peripherial radial discharge, the radial velocity of the air entering the fan, manifesting a very unequal distribution of velocity. In fact, the air is entering radially through only about two-thirds of the runner, and is actually flowing back through the other third.

Drawing Office Novelties.

Brooks' Patent Flexible Curves and Parabola Curve.—We have received from Mr. W. J. Brooks, 33, Fitzroy Square, London, one of his curves, which we have found extremely useful. It consists of a flexible strip of celluloid or steel, provided with tabs at intervals along its whole length. Up to the 8-in. size the curve can be held down in position by placing the fingers of one hand on the tabs while the pen is used with the other. In the larger sizes the tabs are secured by weights or drawing pins. Weights resting on the tabs do not obstruct the ruling pen. In another pattern the strip is of steel, and any shape given to it is retained by means of the stiff-hinged linkwork attached to the tabs. Draughtsmen and teachers of mathematics will also find the parabola curve very useful. The instrument is very accurately cut in transparent celluloid, and its axis, focus, and latus rectum are engraved on it.

Roller Attachment for T*-Squares* (*G. M. Lees' Patent*).—Another useful appliance for the drawing office will be found in a T-square attachment, which is made by Mr. W. H. Harling, 47, Finsbury Pavement, London, E.C. It consists of a small roller, in hemispherical outer casing, fixed close up to the stock of the square; the roller projects slightly below the under surface of the blade, and bears on the drawing board, or on the paper placed thereon. The outer casing, while carrying the roller, also shields it from the hand. By means of this attachment the stock is maintained in better contact with the guiding edge of the drawing board. Friction is reduced, enabling the square to be used more rapidly, and without any of the little annoying refusals to move on the first impulse, especially in damp weather. The drawing is also maintained in a much more cleanly condition. When the drawing board is used at a slope, the T-square with roller fitted does not run down, nor does the roller project sufficiently to allow of set squares getting under the blade. The rollers and casings are neatly got up, and are ready for attachment by almost anyone. A circular hole, $\frac{1}{16}$ in. diameter, must be bored through the blade of the T-square to allow the roller to pass, and the casing is screwed on to the upper surface.